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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES' EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

APRIL 6.

Society of Chemical Industry (Birmingham and Midlands Section):—Annual meeting. "Refractories," Paper by C. R. F. Threlfall and A. T. Green.

Institute of British Foundrymen.

MARCH 25.

East Midlands Branch:—Annual general meeting. Short Paper competition on Papers and discussions during the session.

APRIL 1.

East Midlands Branch (Lincolnshire Section):—Ordinary meeting at Lincoln. "The Sand-Slinger in the Foundry," Paper by A. J. S. Shewan and R. Atchison.

Lancashire Branch:—Annual general meeting at Manchester. "The Making and Use of Graphs for Foundry Purposes," Paper by J. S. G. Primrose.

West Riding of Yorkshire Branch:—Ordinary meeting at Bradford. "Grey-Iron Castings," Paper by F. K. Neath and F. Poole.

APRIL 7.

Birmingham and Coventry and West Midlands Branch:—Annual general meeting at Birmingham.

The Technical Exhibit.

The Technical Committee of the Institute of British Foundrymen has undertaken to stage a non-commercial exhibit at the Foundry Exhibition to be held in the Agricultural Hall from April 24 to May 3. Last Saturday each sub-committee convener outlined his plans to a meeting of the Committee held at St. Pancras Hotel, presided over by Mr. J. W. Gardom, and the mere enumeration of the exhibits promised took well over half an hour. The sub-committees, it will be remembered, cover the subjects of sand, steel, cast iron, non-ferrous, malleable and melting practice, and each has assumed responsibility for a composite exhibit, showing (1) efforts the foundry industry is making to overcome competition from competitive industries; (2) the type of work the committees are carrying out; and (3) trends of modern foundry practice. The exhibits to be staged by the cast-iron committee are typical, and will include, *inter alia*, castings which have replaced forgings; details of international specifications for grey-iron; samples and test-pieces showing Mr. West's work on the influence of phosphorus on cast iron; other samples loaned by Mr. Longden deal with the shrinkage of cast iron as influenced by such factors as pouring temperatures. Recent developments are to be shown, and will include austenitic, martensitic, high-duty, soda-ash treated; heat and corrosion-resisting, nitric cast iron, nickel cast iron. Finally, recommended methods of running will be shown by a series of castings with the runners and risers left on, and chill positions indicated by painting in white.

The section devoted to sands is naturally of a different type. It is proposed to show every piece of apparatus which is currently used by the various members for testing, and, in addition samples illustrative of the production of bond by the sole use of coal dust and clay-free sands as developed by Mr. Hird.

In addition to the Institute's technical exhibit, the British Cast Iron Research Association also have a stand, and that body can be relied upon to create features of outstanding interest to the industry.

Commercial exhibits apart, there is sufficient material on the technical stands to command the serious attention of the industry, and it is obvious that no progressive foundry owner can afford not to visit the exhibition in company with his executive staff.

Porosity of Castings.—II.

It will be evident from our previous issue that in seeking to diminish what is summed up by engineering critics generically as porosity in castings, it is necessary first of all to classify the various types of porosity, and to understand how they arise, because the remedies in the several cases will be different. The reduction of blow-holes is, to a large extent, a question of metal temperature and other practical factors with which founders will be familiar. In some cases gases may be entrapped rather than air, and arising from organic matter or sand in the mould. Shrinkage and contraction cavities can also be dealt with frequently by practical foundry methods, such as by modifying gating and, in many cases, by improving the design of the casting.

For the reduction of graphite cavities we have to look first of all to a reduction in the total carbon content of the metal; secondly, to an increase in the combined carbon content within the limits of machinability; thirdly, to a reduction in the size of the flake. In some cases alloy additions are required; in other cases composition and thickness combined are such as to produce a metal on the verge of unmachinability and special foundry technique is required to ensure greyness.

What we have ventured to term micro-porosity, that is, the capacity for being penetrated by fluids or gases, particularly at elevated temperatures or pressures, which cast iron shares with other materials, probably does not require to be tackled anything like so seriously as the other cases mentioned above, but the increased operating temperatures of engineering plant and equipment is bringing this problem to the front.

The author of the article which inspired these comments referred particularly to corrosion as due to porosity through the permeability of any covering protective film which may be put on the metal. In this respect a large number of small pores is probably worse than a small number of large ones. This has a special significance in relation to graphite size and increased liability to corrosion is one of the few respects in which small-graphite iron is of less value than a larger-graphite iron. The small-graphite iron has a larger number of centres of penetration. The reverse appears to apply where resistance to heat is concerned and where gases penetrate the metal along the graphite flakes. Here a large number of small flakes appears to be definitely more satisfactory than a smaller number of large ones.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

The Balanced Blast Cupola.

To the Editor of The Foundry Trade Journal.

Sir,—In reply to Mr. Roper's letter, published in your issue of March 16, the Papers referred to are doubtless those by Mr. Shepherd (F.T.J., December 29, 1932, and January 5, 1933) and Mr. Wharton (F.T.J., February 16, 1933). In neither case would the cupola diameter or daily tonnage be regarded as large. In the first-mentioned Paper a 27-in. cupola is described, yielding 30 tons per day, and a 26-in. cupola yielding about 24 tons per day. In the latter case a 33-in. cupola is described giving about 25 tons per day. The coke consumption figures recorded have been given by users of these cupolas and are not in any way due to the Cast Iron Research Association, which could not publish figures without the permission of members concerned. It may, however, be stated that probably half of the installations so far made are operating under the conditions for which information is required, that is without technical supervision, on short runs and in comparatively small sizes.

The following figures refer to a 27-in. cupola rated at 3 tons per hr. and actually yielding 3.5 tons per hr. It has run for 170 hrs. in over fifty heats, the average heat being thus about 3 hrs.

	Before Conversion to Balanced Blast.	After Conversion to Balanced Blast.
Coke consumption, including bed ..	10.9 per cent. or 9.2 : 1	8.8 per cent. or 11.4 : 1
Coke consumption, excluding bed ..	9.4 per cent. or 10.6 : 1	7.5 per cent. or 13.3 : 1

The comparison is based on a similar number of heats and hours of melting, both before and after conversion. It will be noted that the bed coke is diminished after conversion from 1.5 per cent. to 1.3 per cent. The total coke is reduced by 2.1 per cent. or 19.3 per cent. of the original consumption. The charge coke is reduced by 1.9 per cent. or 20.2 of the original consumption. The actual consumption figures, which depend on the type of work being done and other local conditions, are, of course, less important than the reduction. The metal is also better, being distinctly higher in temperature, less oxidised, has longer life, and the lining erosion is less and less localised. There is also less trouble through defective castings.

There is no necessity for technical supervision or control of this cupola. The regular cupolaman readily learns during the first run, which is carried out in the presence of the Association's representative, to manipulate the valves, which in ordinary circumstances are not altered during the blow. Actually less attention is needed because tuyere-poking is eliminated.

Should further figures become available I will forward them. Yours, etc.,

J. G. Pearce,
Director.

British Cast Iron Research Association,
St. Paul's Square,
Birmingham.
March 18, 1933.

Selection of Engineering Materials.

To the Editor of The Foundry Trade Journal.

Sir,—I have read with interest the letter from Major Vivian in your current issue. I find some difficulty in replying to Major Vivian, firstly because he does not formulate any definite questions, and secondly because our respective angles of vision on the subject of engineering materials are widely different. The engineering metallurgist, of whose point of view I attempted to give a generalised and idealised account in my Paper, regards a piece of metal from within, with the eye of imagination and a knowledge of the dependence of mechanical properties on metallographic structure. The engineer, on the other hand, is often prone to regard the same piece of metal as a simple entity on which to exercise his skill in stress analysis.

That tensile failure in a metal is due in the first place to slip is not merely very probable, but is an established fact, and the importance of investigations on the complete mechanism of failure under static and dynamic stresses can hardly be over-emphasised. The mechanisms of slip and of slip interference, or stress resistance, are fundamental properties of the metallic state, and are independent of considerations of stress analysis. As to that piscatorial novelty, the metallurgical red herring, I cannot but feel that Major Vivian is far more guilty than I of its introduction when he refers to the identity of the tensile strength of cast iron loaded axially and transversely.

On the question of ductility in cast iron, Major Vivian again misinterprets my point of view. His suggestion of reinforcement with steel rods is essentially unsound in both theory and practice, and calls for no further comment from me. The use of alloy cast irons is not by any means to be construed as a remedy for lack of ductility. In any case, rigidity is more often in demand than ductility in cast iron. If improved plasticity is desired, however, the obvious remedy is to reduce the interruption of the continuity of the ferrite or pearlite matrix, by ensuring a finely-divided graphite and a minimum phosphorus content. Comparisons with mild steel on the score of ductility are hardly pertinent, as the interchangeability of these two materials is not in question, particularly in the branch of engineering with which the writer is connected.

May I say how much I appreciate Major Vivian's interest in my Paper and the undoubted value of his work on stress analysis in cast iron? In the present case, however, I cannot but feel that we are arguing at cross purposes, and I shall accordingly look forward to further discussion on more common ground at some future date.—Yours, etc.,

L. B. Hunt.

Vauxhall Motors, Limited, Luton,
March 20, 1933.

Foundry Costing.

To the Editor of The Foundry Trade Journal.

Sir,—I have followed with considerable interest the correspondence that has been taking place in your columns for some weeks past with reference to the above subject. It seems to me that the majority of people forget the fundamental reason for the existence of costing, and that in the average foundry it is a post-mortem instead of a pre-mortem. I should like to know what some of your readers think on the matter.—Yours, etc.,

P. S. Egerton.

38, Grove Vale,
East Dulwich, S.E.22.
March 17, 1933.

Phosphorus in Cast Iron.

To the Editor of The Foundry Trade Journal.

Sir,—The report of my contribution to the discussion on phosphorus in cast iron is incorrect. I could not have said that sulphur is an exception to other elements in cast iron and does not influence the freezing range. Also the last paragraph referring to the use of the metallurgist and refined irons is not a statement of mine.

Yours, etc.,

E. Longden.

11, Welton Avenue, Didsbury Park,
Manchester.
March 17, 1933.

Random Shots.

Shades of Stradivarius and Amati! "Marksman" reads that aluminium violins are now being produced on a commercial scale in a plant at Buffalo, U.S.A. The two panels—front and back—the neck and key sections, are stamped from 51S sheet, and the scroll is made up of two thin die castings in 43 alloy. The parts are assembled by welding, and then enamelled, varnished and finally oil-polished. These aluminium instruments are claimed to be comparable to the best modern violins of wood.

* * *

There seems to be no reason now why the steel guitar shouldn't literally live up to its name.

* * *

A society for the prevention of gossip, says a morning newspaper, has been started in a village in Somerset. The idea is not original, as the ducking stools still existing in various parts of the country testify. Suspected gossipers will be brought up at a mock trial, to be held in the village. To "Marksman" this system seems to have a serious disadvantage, in that the process of deciding whether a person were a gossiper would probably entail a goodly volume of gossip itself. One is reminded of the story of the shop girls: "What a gossip Betty is, she talks all the day," said one to another. "Whom does she talk to?" "Why, me, of course!"

* * *

A curious error crept into the catalogue of the Birmingham Section of the British Industries Fair—"Marksman" noted it last year, as well—namely, the words "ferrous" and "non-ferrous" are spelt as "ferreous" and "non-ferreous." This is the very last mistake one would expect to see in a catalogue emanating from Birmingham.

* * *

Miss Nellie Snookers is "in the news" once again. "Marksman" hears that she has been appointed honorary secretary of a new association—the Society for the Beautification or Suppression of Rural Gasometers. The Society's slogan, you may care to know, is adapted from one of "rare Ben Jonson's" lovely couplets:—

"If you love the sweet countrie,
Join the S.B.S.R.G."

The Society's plans are well advanced. They include a campaign which will press for the decoration of rural gasometers so that they harmonise with their surroundings. A gasometer situated in a woodland district, they urge, should have woodland scenery painted over its surface. Controversy was rampant when gasometers standing in flat country were considered. The final decision was that since they could not possibly be beautified or camouflaged, they should be suppressed. Voluntary supporters of the Society are now being appealed for.

* * *

"Your Worship," said the witness, "you may take my statement as being absolutely correct. I have been wedded to truth since I was a child."

"Quite possibly," said the Judge. "But now tell the court for how long you have been a widower."

* * *

"How about some nice horseradish?" said the grocer to the bride.

"Oh, no, indeed; we keep a car."

Marksman.

The Wear of Cast Iron.*

By F. K. Neath, B.Sc. (Keighley).

The ability of cast iron to withstand frictional wear under lubricated conditions has always been of great value to engineers, and where lubrication is not possible or desirable, it has been found that cast iron will give superior service life over many other alloys. The conditions under which cast iron is used in industry and which involve wear are complex and varied, and it is proposed in the present Paper to review the published work of the various investigators who have studied the subject from the metallurgical aspect. It is not proposed to consider white or chilled cast irons in this survey, as such irons

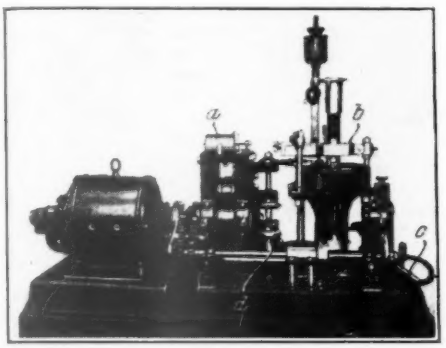

Fig. 1.—Wear-testing Machine at Aachen Foundry High School.

a—Mechanism for roller friction. *b*—Disc for sliding friction test. *c*—Circular saw for cutting friction tests. *d*—Abrasion test (sand, emery).

are generally unmachinable under ordinary machine-shop conditions.

Phosphorus as a Factor in Wear Resistance.

Many opinions have been given from time to time on the factors which control the wear resistance of cast iron. For instance, it has been stated that the graphite flakes which are the predominating features of grey cast iron, act as a lubricant when a cast-iron surface is subjected to any rubbing or rolling action. This view has been opposed by the argument that the amount of graphite present on a cast-iron surface is not sufficient to function as a lubricant

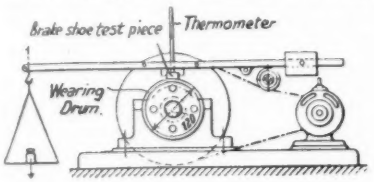

Fig. 2.—Brake Shoe Type of Wear Testing Machine.

for long periods. Another view is that the phosphorus constituent of cast iron is relatively harder than the remainder of the metal and so acts in manner similar to a bearing metal where the hard crystals stand out in relief and carry the load while the softer matrix beds down to the required shape. In a soft cast iron with large graphite flakes and a soft ferritic matrix, this explanation certainly appears very convincing. One of the first investigators in this country to examine the question of the wear of cast iron was J. E. Hurst[1] whose work is published in the Carnegie Scholarship Memoirs of 1918. This investigator points out that a feature of cast iron working under conditions of rubbing and sliding is the formation of a glazed surface which apparently has good wear-resisting properties. It is also pointed out that the actual surface finish of the wearing faces of a casting before going into service plays an important part in the formation of such a glaze.

The Incidence of Work Hardening.

The author has frequently heard it said that the excellent wearing properties of cast-iron steam cylinders and similar parts in the past, has been due to the formation of this glaze, and that the slow running in of the engine before going into service is an important factor in the production of this glazed surface. The recent work of E. G. Herbert[2] on the work-hardening of metals is interesting in this connection, as this investigator has shown that the induced hardness on the surface of a metal caused by an oscillating pressure is comparable to the actual hardness found at the surface of steel rails, gear teeth, etc., after periods of service.

The increasing demands of modern engineering practice have resulted in greater discrimination being exercised in the selection of engineering materials. An outstanding example of this, with regard to cast iron, is the modern internal-combustion engine. The rapid development of the motor car and the severe working conditions of the Diesel engine have brought, with prominence, that fact that cast-iron cylinders, pistons and piston rings wear away in service much more rapidly than is now desirable, and although this

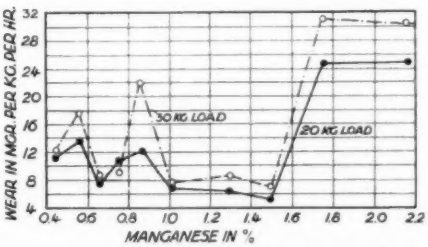

Fig. 3.—Influence of Manganese on Wear of Brake-Blocks.

problem is not by any means new, there is no doubt that it is at present causing serious concern among the designers of internal-combustion engines. The use of cylinder liners made from heat-treated cast iron, with Brinell hardness values hitherto unthought of for cast iron, shows the importance of the problem. In a recent Paper to the Diesel Users' Association, Harrison[3] shows that wear of Diesel-engine liners is mainly due to difficulties of lubrication or mechanical faults, but until these can be overcome the wear-resisting properties of the material will be of great importance.

In considering wear problems, the reciprocal nature of the wearing action is often overlooked. It is obvious that when two bodies are in frictional contact that both will tend to be worn away, although the amount of actual wearing away experienced by each will depend on their respective natures and the conditions under which they are in contact. Under some conditions, such as a steel shaft in brass bearings, it is obviously desirable to confine the greater part of wear to the bearing which can readily be replaced or adjusted, rather than have the steel shaft reduced in diameter, due to wearing away. In other cases it may be just as desirable to have the wear equally distributed between the parts in frictional contact. In making wear tests, the comparative rate of wear of two materials against a third material is not always a reliable guide, especially if the amount of wear of the third material is not considered. The following summary of the chief methods used for testing the wear of cast iron refers to work carried out during the last 15 years or so, and which has been published in the various technical journals.

Methods Used for Wear Testing.

In making tests on cast iron for wear resistance, many investigators have tried to simulate particular service conditions, but, unfortunately, in the case of lubricated-service conditions the time involved to obtain useful results has rendered the tests extremely tedious. This has resulted in the use of unlubricated conditions for testing, in order to obtain more rapid results. The chief methods in use are enumerated below.

Rotating-Ring Test.

A steel or cast-iron ring, such as a piston ring about 6 or 12 in. dia., is mounted on a horizontal plate and rotated about a vertical axis.

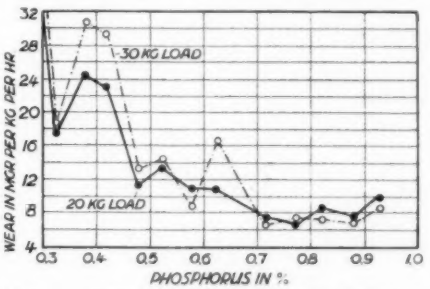

Fig. 4.—Influence of Phosphorus on Wear of Brake-Blocks.

The specimen of cast iron to be tested consists of a round or square test-piece, usually not more than ¼-in. sq. in cross-sectional area, which is held stationary and is pressed against the flat edge of the rotating ring at a uniform pressure. The amount of wear is taken as the loss of weight or decrease in length of the specimen after several hours' running. The rate of wear under these conditions of test is not always uniform, and often varies during the run. This method has been used by Hurst,[1] Swift,[4] B.C.I.R.A., West and others.

Brake-Shoe Test.

In this test the specimen is again stationary, and presses against a rotating steel or cast-iron drum in a manner similar to the brake shoe on the wheel of a railway truck. The loss of weight

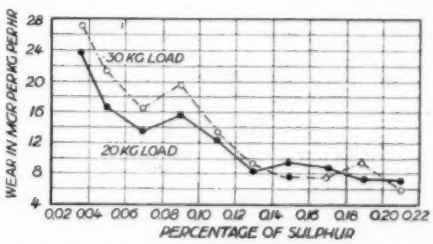

Fig. 5.—Influence of Sulphur on Wear of Brake-Blocks.

or decrease in length of the specimen is taken as a measure of the wear. In this test it is customary to start with a flat-ended test-piece and to allow a preliminary running-in period to enable the end of the test-piece to take up the shape of the curved drum. This test has been used by many European investigators, particularly Lehmann,[5] Klingenstein,[6] and Scharffenberg,[7] and in this country by Rolfe[4] (lubricated).

Blunt Drill Test.

A bar of cast iron, about ½ in. dia., is faced off square at one end and placed in the chuck of drilling machine. The "blunt drill" thus provided is allowed to drill into a plate of cast iron or steel placed on the table of the machine. The speed and drilling pressure of the machine

* A Paper read before the Middlesbrough Branch of the Institute of British Foundrymen.

are controlled and the loss of weight of both "drill" and plate are measured after ten minutes' drilling. The question of the appearance and influence of particles of worn material, etc., has been studied by this test. As far as the author knows, this test has only been used by Klingenstein[9] in Germany, and the results obtained are very interesting, as will be seen later.

Reciprocating Test.

A number of investigators have used a reciprocating wear test in which the specimen is rubbed backwards and forwards over a surface of steel or cast iron under uniform pressure. The amount of wear is measured by weighing or measuring the specimen after a given time. The method has been described by Hurst[1] and

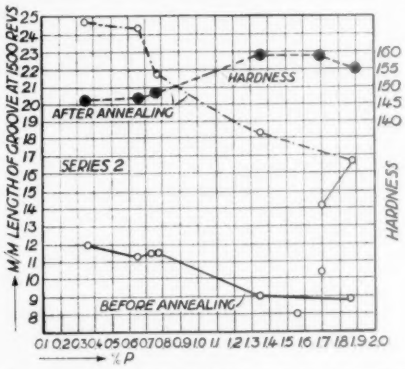

Fig. 6.—Influence of Phosphorus on Wear of Pearlitic Cast Irons.

Rolfe[5] (lubricated) and is intended to represent conditions such as obtain in the cylinder of reciprocating engine.

Rolling and Sliding Friction.

A wear-testing machine is marketed by the Swiss firm of Ansler in which two small rollers run in contact with each other and in opposite directions. The pressure is kept uniform, but one roller may be run at slower speed than the other, to give 1 per cent. slip, thus giving a partial sliding friction. Lubrication and abrasives may be applied if desired. This test has been used by Piwowarsky[10] and other German investigators.

Spindel Test.

A flat specimen is held under constant pressure against the edge of a rotating disc 1 mm. thick.

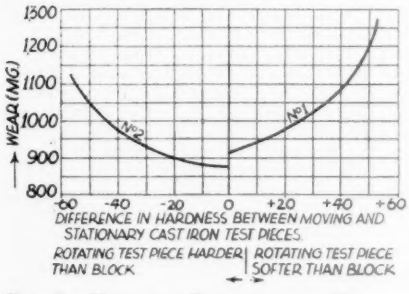
WEAR (MG)
No 2
No 1
DIFFERENCE IN HARDNESS BETWEEN MOVING AND STATIONARY CAST IRON TEST PIECES.
ROTATING TEST PIECE HARDER THAN BLOCK
ROTATING TEST PIECE SOFTER THAN BLOCK

Fig. 7.—Effect of Difference in Hardness on Wear.

The disc acts as a blunt circular saw and the amount of wear is measured as the volume of the impression made, while the amount of wearing away of the steel disc may also be measured if desired.

Abrasion Tests.

In some of the above test methods an additional factor has been incorporated by the feeding in of an abrasive powder with water or oil to accelerate wear or to imitate special service conditions. Tests under such conditions have been described by Piwowarsky and Weiss.[11]

It is interesting to note that at the Technical High School, at Aachen, Prof. Piwowarsky[12] has installed a wear-testing machine in which tests under rolling friction, sliding friction, cutting friction (spindel method) and lubricated or abrasive friction, can be carried out (Fig. 1).

Service Tests.

Undoubtedly the most convincing test of the wearing qualities of a cast iron is the "service" test. Unfortunately the difficulty of ensuring uniform conditions or of even knowing what the conditions actually are during such a test, make single tests of this type uncertain and only the average of a large number of tests can be taken as truly representative. Information gained in this way becomes accumulated experience rather than test data and takes a long time. An interesting example of the way in which service tests can be made is an investigation undertaken by the German State Railways.

(1) To investigate the wear of brake blocks, ten trains comprising 130 wagons were fitted with blocks from different makers, the composition being known. After running 30,000 miles the loss of weight of the blocks was measured and also the amount of wear on the steel tyres.

(2) The wear of locomotive piston valves was studied by measuring the loss of weight or change of size of piston rings and valve chests before and after long periods of service. The results were correlated with Brinell hardness.

Results of Wear Tests.

In considering the results of wear tests it is necessary to bear in mind the nature of the test used and also the service conditions for which the cast iron tested is intended. The use of

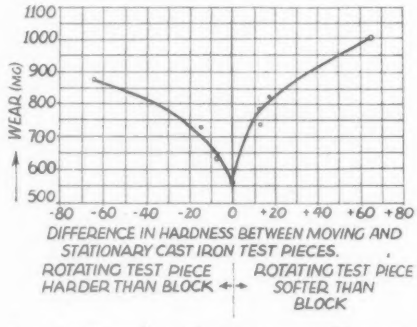
WEAR (MG)
DIFFERENCE IN HARDNESS BETWEEN MOVING AND STATIONARY CAST IRON TEST PIECES.
ROTATING TEST PIECE HARDER THAN BLOCK
ROTATING TEST PIECE SOFTER THAN BLOCK

Fig. 8.—Effect of Difference in Hardness on Wear.

unlubricated tests is often criticised when the results are interpreted into probably service behaviour under lubricated conditions. The comparatively short time required to obtain results by the unlubricated test has, however, led many investigators to use this test. For dry wear service conditions, however, the results are much more comparable. Tests of this type were carried out by the German State Railways in connection with the service tests mentioned above. The type of machine used is shown in Fig. 2.

The tests were carried out by Lehmann[8] in 1926, using both steel and cast-iron hubs, and the results show: (1) Wear resistance increases with pearlite content; (2) phosphide eutectic has a harmful influence, as particles become detached and form a grinding substance; (3) with cast iron wearing against cast iron graphite acts as a lubricant and diminishes wear, and (4) neither chemical composition nor Brinell hardness is definitely related to wear.

This investigator confirmed Hurst's findings regarding the formation of a glazed surface which he attributed to the material rubbed off filling the cavities formed. Similar tests were made later by Scharffenberg[7] using the machine illustration in Fig. 2 fitted with a steel drum, and his results are shown in Figs. 3, 4 and 5. It is seen that manganese gives a minimum of wear at 1 to 1½ per cent., while phosphorus and sulphur give diminished wear as the percentage of these elements increases. The service tests on brake block wear also confirmed that pearlitic structures gave a minimum of wear on the brake blocks and tyres, while softer irons wore away more rapidly.

The above-mentioned tests were conducted under conditions representing the service conditions of the cast irons tested. This type of test has been largely used on engineering cast irons such as cylinder iron, which would be lubricated in service. For instance, Lowry[13] has reported tests on American irons using a "brake-shoe" test with water cooling to keep uniform temperature. When hard cast iron was tested against soft cast iron the soft iron took on a glaze and after 1,000 hrs. had worn less than the harder iron. Increased phosphorus was found to give increased wear resistance.

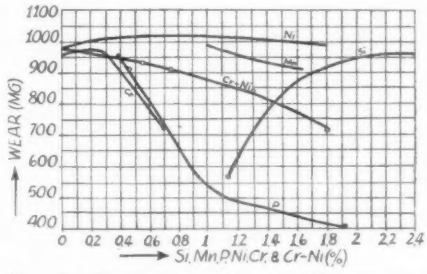

Fig. 9.—Influence of various Elements on Wear.

Piwowarsky[10] studied the influence of phosphorus using Amsler (rolling friction) and Spindel (cutting friction) machines, under both dry and lubricated conditions. The results of both series of tests were similar and showed that increasing phosphorus from 0.1 to 0.75 per cent. gave increased wear resistance. Klingenstein[9] has carried out tests on phosphorus using a "brake-shoe" type of test with a steel drum, and some of his results are given in Fig. 6. He experimented with soft ferritic cast irons with a Brinell hardness of below 160 and also with a pearlite series (Brinell 210 to 240), before and after annealing at 950 deg. C. In the soft-iron series the wear was halved by increasing the phosphorus from 0.25 to 0.75 per cent., after which no further influence was found. With the pearlite series the wear was less than the ferritic series and required a higher phosphorus content (over 1.0 per cent.) to give any marked improvement.

Wear and Hardness.

A number of workers have tried to relate wear to Brinell hardness. The last-mentioned inves-

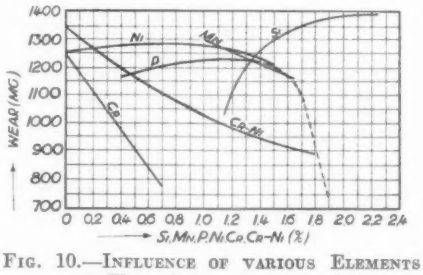

Fig. 10.—Influence of various Elements on Wear (after Annealing).

tigator could find no definite relationship, however, except that cast iron with a pearlitic structure gave better wear resistance than softer cast irons containing ferrite and having a lower Brinell value. Nickel and chromium additions gave an improvement in wear resistance due to the harder ground mass. Reide[14] has also reported tests with cylinder cast irons, using a "brake-shoe" test with a steel drum. No relation between wear, drill hardness (machinability) and Brinell hardness could be found. Nickel additions gave much more uniform results over a series of tests but the actual amount of wear was not seriously influenced.

Locomotive Piston Valve Tests.

In the service tests with locomotive piston valves mentioned above, it was found that the largest number of failures with rings was recorded with those having a Brinell hardness below 140. The difference in hardness between the ring and the valve chest also influenced the wear. The best results were obtained when the ring had a Brinell hardness of some 10 points lower than that of the valve chest. A rather ingenious test developed by Klingenstein[9] has already been mentioned, viz.: the use of a blunt drill of cast iron against a plate of cast iron or steel. The results of this test are very interesting (Fig. 7). For cast irons about 180 Brinell show the wear obtained plotted against the difference in hardness between the "blunt drill" and the plate.

It will be noticed that the minimum wear occurs when the two parts are of equal hardness. Fig. 8 shows the similar results with higher-quality cast iron, the Brinell hardness in this case being about 230. Fig. 9 shows the influence of the various elements and Fig. 10 the results after annealing at 900 deg. C. for three hours. This series of tests also showed a good relation between wear and Brinell hardness. Observations with this "blunt-drill" test on the time taken for the appearance of visible signs of wear (particles of worn material) showed that surface finish of the softer series did not

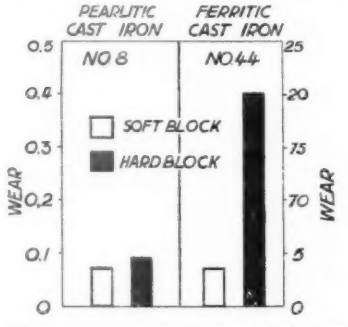

Fig. 11.—Influence of Relative Hardness of Test-piece and Wearing Block.

have much influence, but with the higher-quality irons polishing the surfaces with fine emery considerably delayed the setting in of wear. The explanation offered is that the pearlitic irons have not such a plastic matrix as the ferritic irons, and therefore cannot take up a glaze so readily. The importance of this in the finishing processes for high-quality cast-iron wearing faces is emphasised. The use of molybdenum up to 1.5 per cent. has been shown by Italian investigators[15] to give considerably improved wear resistance to cast iron, as measured by the Amsler test (rolling friction).

The tests described above indicate to some extent that the reciprocal nature of wear is important. This is confirmed by Piwowarsky,[12] as shown in Fig. 11, the increased wear of a soft cast iron against a harder wearing drum being very marked.

Some American tests by Boegehold,[16] using a "brake-shoe" test (unlubricated) on cylinder irons, shows that wear decreases with increasing combined carbon content up to 0.75 per cent. With service tests of 20,000 miles on motor cylinders running under normal conditions of lubrication, no measurable difference in wear could be detected between annealed and unannealed cylinders. Tests with cylinders from different makers suggested that increasing silicon content of the metal gave increased wear. Bornstein[17] states that tractor cylinders, tested to give accelerated wear by diluting the lubricant and feeding dust into the cylinders during running, gave a more uniform and a lower rate of wear when nickel and chromium additions were made to the castings.

Practically the whole of the above-mentioned tests have been made without lubrication. Test results given by Rolfe in his treatise on "Foundrywork and Metallurgy" deal with lubricated tests and suggest that a pearlitic iron gives a better resistance to wear than softer irons. The use of an abrasive powder in wear tests has been described by Weiss.[11] The abrasive was fed in with water and it was found that a soft grey iron (150 Brinell) was better than a good grey iron (190 Brinell).

Conclusions.

The above summary of wear-test results shows conflicting views on the wear resistance of cast iron. The question of the influence of graphite size and distribution has been considered by some of the investigators mentioned, but the results have not been conclusive. The general opinion appears to be that the pearlitic condition gives good wear resistance, and that phosphorus and possibly sulphur and manganese are elements which are favourable to wear resistance. The use of nickel and chromium, both together or individually, is becoming more general for castings which have to withstand wear. In this country a number of investigators are carrying out wear tests on cast iron. Dr. Swift,[4] of Bradford, has already published some of his results and further work is in progress. The author has been privileged to see wear-testing investigations in progress at several engineering works and institutions, and it is to be hoped that the work in hand will throw light on to what is at present a somewhat baffling problem.

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DISCUSSION.

Mr. R. J. H. Ritchie said that he was interested in the lecturer's remarks as he had had two instances where cast iron had shown good wearing properties as compared with other metals. One was a phosphor-bronze nut in a planing machine and the other a phosphor-bronze wheel working against a steel worm. In both cases rapid wear was experienced and replacement by cast-iron parts had solved the problem in both cases.

Mr. C. B. McCusker asked if there was any difference in wear in motor cylinders when cast in oil-sand moulds as against green-sand moulds.

The Lecturer replied that he had no information on this subject, but that some firms had used the oil-sand method for cylinder castings and would probably have records regarding wear.

Mr. F. P. Wilson remarked that the information which the lecturer had given on brake blocks was most interesting, and the action of phosphorus in the wear of brake blocks was apparently very significant.

Mr. Wilson's remarks were reiterated by the Chairman, who stated that the Paper had shown quite clearly that phosphorus played an important part in the wear-resistance of cast iron.

Mr. N. D. Ridsdale commented on the fact that the pearlitic condition apparently was favourable for castings required to withstand wear, and quoted an instance where the pearlitic condition of a cylinder liner was assumed from the combined carbon content of a test-bar which had a smaller cross section than the liner casting. The actual casting had a lower combined carbon content, of course, and when the error was discovered the liners were made with a higher combined carbon content which resulted in better wear in service.

Mr. A. Scholes, F.I.C., asked the lecturer if he had any further information on the influence of graphite on wear. Also, was it sound practice to use the results of dry-wear tests for cast iron to work under lubricated conditions?

In reply, the Lecturer stated that there was some evidence to show that long thin graphite flakes gave better wear resistance than short thick flakes, but the subject had not been studied as fully as its importance deserved. With regard to dry *versus* lubricated tests, he agreed with the speaker that dry tests were perhaps misleading. However, it had been stated by competent engineers that with perfect lubrication there should be no wear. It was therefore merely a matter of degree of lubrication

Mr. J. E. Mercer gave instances where the method of melting the metal for chilled rolls had influenced the wear of the rolls in service. When an open-hearth furnace was used a fine black fracture was obtained behind the chill and the wear of the rolls was unsatisfactory. With cupola melting the fracture was normal and good service life was obtained.

The Lecturer replied that Mr. Mercer's experience with melting roll metal could be explained by recent research work and the influence of melting on the distribution of graphite was now becoming an important factor.

A vote of thanks to the lecturer was moved by Mr. A. Scholes and was carried with acclamation.

Critical Situation in the French Foundry Industry.

The parlous condition in which the French foundry industry finds itself is shown by a letter which has appeared in several French newspapers, and of which the following is a translation.

Mr. Charles Dufour, the President of the French Foundry Employers' Federation, has sent the following letter to the French Prime Minister:—

Sir,—As, at the moment, Parliament is discussing the Budget, the French Foundry Employers' Federation (Iron, Steel, Aluminium, Die Castings, Brass, Bronze and Malleable) respectfully submit the following observations:—

(1) Three years ago the foundry industry possessed 1,500 works. To-day it is estimated that 15 per cent. have now closed their doors.

(2) At that time the French foundry industry found employment for 100,000 workpeople and their families; to-day this figure has been lowered by more than 30 per cent., and those works which, at the cost of much sacrifice, have been able to carry on are only working in many cases for two days per week.

(3) For several years the total amount of business done in the foundry industry approached 3 milliard francs. It is extremely difficult to estimate the reduction of this figure, but it will be sufficient to inform you that nearly all the engineering foundries are working from hand to mouth and are only producing on two or three days per week. A good number of foundries await the morning's post to know if they can engage their workmen for the whole of the day. The sole fact that all the orders from public bodies and railway companies are, at the moment, completely stopped is sufficient to justify this situation. Not wishing to take up the arguments of a general character, which have been many times set out and developed, we would ask you to consider the grave situation in an industry, which is the basis of national defence and which to-day have reached the limit of its possibilities, it expects from the Government no measures of an aggravating character but decisions which will allow it to recover its prosperity.—Yours, etc.,

Charles Dufour,
President.

Making a Large Ingot Mould.

By J. Roxburgh.

The making of a large ingot mould is not, of course, an everyday job, nor is it merely a question of unusual mass, with its attendant complications, but rather a matter demanding painstaking attention to detail in order to produce a satisfactory casting. The thought of "chancing" anything must be dispelled from the mind initially. It must at once be assumed that the necessary manufacturing facilities are available—the melting plant, the moulding tackle, the lifting gear and the transport. To start without these primary requisites is not merely foolish but dangerous. So far as the metal goes, it is a matter of obtaining the quantity at the correct temperature. Taking into consideration the 6 in. of head incorporated on the casting to ensure solidity, and allowing a surplus for contingencies, a 120-ton ingot mould, for instance, means approximately 135 tons of metal.

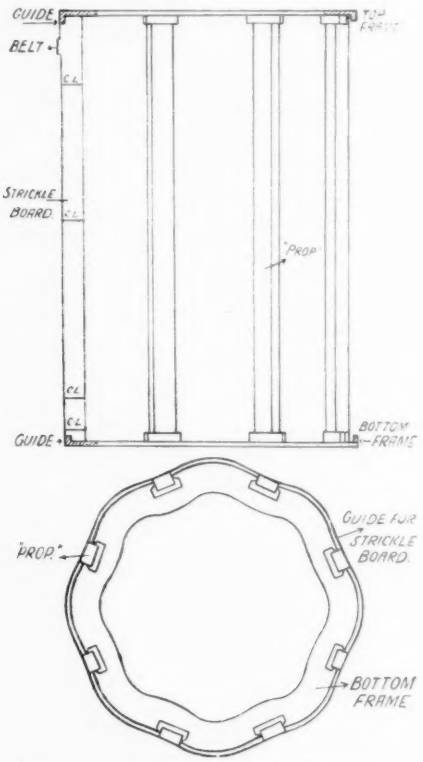


Fig. 1.—Showing Skeleton Pattern.

It has been found that the first metal tapped, being of the composition it is, will not stand more than four to five hours and hence it means roughly that all the metal must be ready in the ladles, preparatory to pouring, in that time. In short, it necessitates the iron being melted at the rate of 35 tons per hour, equivalent to the simultaneous running of two 10-tons per hr. and two 8-tons per hr. cupolas. If one can improve upon this time by melting in one or two air-furnaces, so much the better, as, incidentally, too, it saves some little anxiety as to whether the cupolas will do all they should.

After that, there is the question of the ladles for the metal, and in this particular case two stand ladles, 40 and 35 tons capacity respectively, were used and four tip-ladles, one 23 tons, two 17 tons and one 12 tons.

Then there is to be considered the "handling" tackle, the cranes, chains, slings, etc. Founders might perhaps pride themselves on what their cranes will do above their capacity, but, unless there is a 150-ton crane, it is better not to bother with the casting in question. For lifting, two wire ropes, twisted together to form a loop 3 in. dia. and 9 or 10 ft. long, are easily the best proposition, as they can the more readily be pushed into position, and are not so liable to break as chains in the event of a sudden jolt. The large tanked pit and special tackle for the actual moulding process will be referred to later.

It is best to consider next, even before starting moulding, the arrangements for transport. A 120-ton casting is definitely not a thing that can be sent away casually. If a railway company does the job it will want time to arrange for special trucks and to see that the line will be clear. Usually, its officials arrange that it shall be a week-end job, wherever its destination. If it is possible to send the casting by road, there is again a good deal of preparation and arrangement as to roads, bridges, traffic and the necessary power—not counting the multitude of officials who harass the poor contractor in their control of the traffic *en route*. Moreover, trouble can be expected should the road suffer damage through this mournful procession!

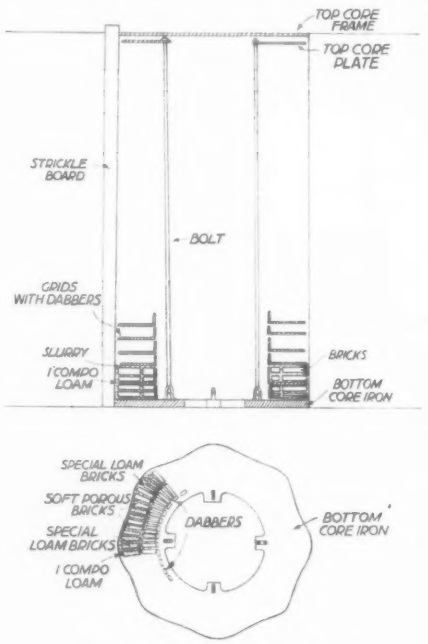


Fig. 2.—Building the Core.

In the main, these ingot moulds are fairly simple in design and certainly not intricate. The exact shape depends principally upon the purpose for which they are intended, and, as usual, the moulds differ in dimensions according to the whims of the individual firm. Some are round exteriorly with an octagonal core, some octagonal inside and out, and some slablike. Since they are all made for the purpose of holding molten steel, it is evident that the metallurgical aspect of ingot moulds is a vital question, the repeated heatings and coolings demanding analyses which are not easily obtained.

Compositional Considerations.

Let any founder consider 135 tons of metal of, say, T.C. above 3.6, Si 1.5 to 1.8, Mn 0.5 to 0.8, S 0.05 and P 0.05 per cent., and he will realise the difficulties which confront him. In the first place, should the steel manufacturer insist upon a maximum content for sulphur and phosphorus of 0.05 per cent., it means the purchase of special hematite pig-iron, containing 0.02 per cent. sulphur maximum, to allow for the gain of approximately 0.03 per cent. S, which occurs in cupola melting. Again, the use of this special pig brings trouble in its trail due to its high carbon content and subsequent separation of "kish," and requires special attention to casting temperature and speedy handling. On the other hand, if no special analysis is insisted upon, the matter becomes easier. In that case, the cupola charge could be 25 per cent. ingot mould scrap and 75 per cent. ordinary hematite giving a sulphur content of 0.07 to 0.08 per cent.

A drawback to these higher sulphur moulds, however, is that only a small percentage can be introduced as scrap in the making of other moulds in the foundry, and, again, the moulds, having completed their lives in the steel melting shop, do not permit of being melted up again for steelmaking under acid-hearth conditions.

Should air furnaces be available in the foundry, larger percentages of this particular scrap can be used up, as no sulphur gain is registered under such conditions of melting. Though here the loss of total carbon and silicon creates another problem, and the author would not recommend more than 30 per cent. of the total metal required for casting being obtained in this manner. Of course, the silicon and manganese losses can be rectified by the addition of suitable amounts of ferro-silicon and ferro-manganese, but the loss of total carbon is a more serious matter, and one which cannot be adjusted very well in the furnace.

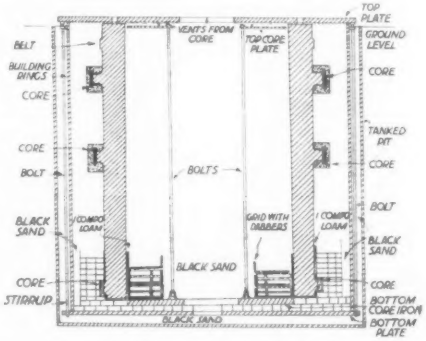


Fig. 3.—Section of the Mould.

Naturally, opinions vary regarding the most suitable analysis for an ingot mould, but if the approximate analysis previously mentioned be aimed at, the resulting structure, consisting primarily of ferrite and graphite, will be found to give results consistent with ordinary practice. Such an iron is able to withstand the alternate expansion and contraction, due to heating and cooling, with less fear of the mould cracking—an eventuality which would have dire results when dealing with such large quantities of steel.

Making the Casting.

Regarding the casting itself, it is true that it is the inside which really matters, because that is the important surface, but any core which has to withstand 125 tons of metal around it and be cleaned out to leave a regular and sound casting is, obviously, something of a problem. It must strip perfectly cleanly, be true to shape and show neither scab, blowhole nor any defect whatsoever.

Coming to the manufacture of the casting, which in this particular case is octagonal both outside and inside, the mould is built up in a large tanked pit 15 or 16 ft. dia. and 18 or 20 ft. deep, as the casting measures 9 or 10 ft. across and 13 or 14 ft. deep. A bottom plate is placed on a sand bottom, previously rammed, in the pit, and the wooden print for location of the

core is bedded in bricks and loam and a level seating swept in loam and dried.

A wooden frame, the exact dimensions of the outside of the casting, is then placed on this seating, and substantial wooden "props" are erected thereon to carry the top wooden frame, thus forming a kind of skeleton pattern (Fig. 1). The vertical board for strickling is simply a straight edge cut away to suit the guides, of rectangular section, screwed on to the outside edge of the top and bottom frames.

The bricking is now commenced and it is important to note that special, soft, porous bricks must be brought into service to prevent any possibility of scabbing, and, it has been found that ashes can be dispensed with between the brickwork, except, of course, on the bottom plate. Venting is taken care of and provision made for the vents to be led off the outside of the mould in accordance with ordinary practice.

Any lugs or bosses required on the casting are formed in cores and located from centre lines on the strickle board and on the frames. The bricks are faced with about an inch of loam, which consists essentially of a special brand of Sheffield steel-moulders' composition, a material selected on account of its refractoriness. At times it will be found that the steel manufacturer asks for a circular belt to be cast on the ingot mould a short distance from the top and bottom, but this complication presents no real difficulty as the bottom belt can be formed in segment cores, whilst the top belt, if so desired, can be struck by a strickle board from a centre spindle. It is understood that steel tyres are subsequently shrunk on these belts further to strengthen the castings.

It is usual practice to build up the mould in substantial building rings, and for the space between the outside of these rings and the inside of the pit to be rammed up with black sand after the top ring has been bolted down to the bottom plate with eight strong bolts. Occasionally, owing to the size of the castings, the brickwork itself has to be taken to the inside face of the pit.

After the mould has been completely bricked and loamed, the skeleton pattern is dismantled and withdrawn. The moulder now proceeds to finish the mould preparatory to blacking, and any lettering or identification marks stamped on at this stage. The best carbon blacking is utilised, having been mixed with claywash, a little plumbago and a small "pinch" of salt.

The drying of the mould is a tedious job, taking at least ten days, and is usually effected by a coke-grate fire. The top plate, provided with holes for the runners and risers, is struck up with the "compo" loam, to which attention has previously been drawn.

Coremaking.

Whilst the moulders are busy with the outside, another gang of men is proceeding with the core, really the most important part of the whole job (Fig. 2). It is quite a simple matter to get the correct dimensions of the core, the procedure usually adopted being the use of a bottom core iron, with staples, and accurately cast from a pattern, and a corresponding wooden top frame, supported at the correct height and relative to the bottom core iron, and with a straight-edge strickle run on the outside of these two frames.

It is a difficult problem, however, to ensure a strong core and one, at the same time, able to take care of the contraction stresses. With this in view, the core is built up with brick and loam, and grids with dabbers cast on, are placed at 8-in. intervals as the core ascends, which materially strengthens the core, whilst loam bricks, of special shape and size, are inserted at the corners and centre of the "flats" of the core, with soft bricks in the intervening spaces, a procedure essential to ensure success. Again, in order to prevent any irregular squeezing of the core, which would make it impossible to obtain the smooth surface insisted upon, the bricks should be packed to the dabbers of the grids—another point of vital importance.

The core is faced with an inch of loam, steel moulders composition, finished, and blacked with similar blacking to that previously described. top plate, which has been built in a few inches from the top of the core is bolted down to the bottom core iron—a further precaution to ensure the rigidity of the core, which is now ready to be lifted into the stove for drying.

When the management is satisfied that the mould and core are perfectly dry, it is ready to commence closing and the core is taken from the stove and accurately located in the print (Fig. 3). The inside of the core is now rammed up with black sand, and the vents brought up to the top. Special attention must be paid to this point as the venting of the core is a special feature of such a job and long rods, withdrawn after the ramming is complete, provide the outlets for the vents.

The top plate is next tried on, and a good touch ensured, so as to avoid any metal gaining access to the inside of the core; it is then packed and securely bolted to the lugs of the top building ring. The next step is to put the stand ladles, runner dishes and riser bushes in their respective positions and to place weights, approximately totalling 80 tons, on the top plate to counteract the lifting.

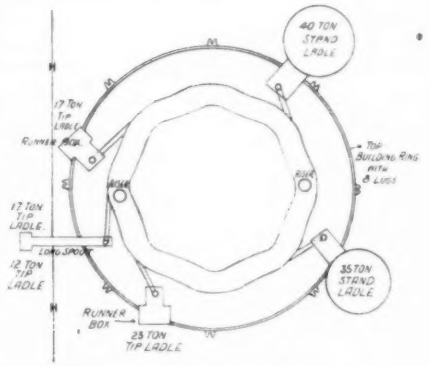


Fig. 4.—Method of Running.

Experience has shown that the running of a job either makes or mars the resulting casting and especially does this apply in this case. From Fig. 4 will be noted the position of the runners and ladles, the capacity of which has been referred to previously, and also that it is necessary to take a long spout runner into the next bay because the other cranes are all being utilised.

In all cases the downgates should be 6 in. dia. and the ingates of a tapered rectangular section, and set at a tangent to the mould, so as to prevent the stream of metal impinging on the corners of the core and to impart a uniform swirling motion to the metal.

If this swirl is not maintained throughout the running, it will probably be found that some scum or dirt has been trapped against the core, and so it is advisable to place the ingates from the stand ladles as near the bottom of the mould as possible, and those from the tip ladles' downgates at higher levels to speed up the flow of metal, which before it reaches these latter ingates is tending to lag.

And so the great day arrives, and it is taken for granted that the management has taken infinite precautions to see that everything appertaining to the job is in "apple-pie" order. The cranes have been overhauled, the cupolas and blowers inspected, the ladle gears well greased, the air furnaces in good repair, a plentiful supply of common blacking to keep the metal warm, and one fervently hopes that the plug in the stand ladle will behave itself!

It takes 4 or 5 hrs. to collect the metal, but only a few minutes to cast the job. A good cast and the suspense is over for the time being, at any rate. The cupolette is kept busy for a few hours supplying metal for feeding, and then the casting is left alone for three weeks. Then comes the releasing and the clearing of the outside and inside finally for the casting to be landed safely on ground level. The fettlers soon are busy and before long the casting is ready for despatch.

Catalogue Received.

Steels.—Thos. Firth & John Brown, Limited, Atlas and Norfolk Works, Sheffield, have sent us a 60-page well-illustrated catalogue, covering all types of steel from acid open-hearth to a range used for casting. We congratulate whoever is responsible for this production on the three pages of letterpress, which serve as an introduction. We were specially intrigued with the phrase used when dealing with the Brown-Firth Research Laboratories, which reads, "The whole of the various branches of science which can react upon, or be reflected in, the properties or behaviour of steel under service conditions are here focused for the advantage of our clients." We have but one criticism to make of this section, and that is the foundry department is dismissed with the phrase "our foundries are extensive and are equipped with the most-modern appliances." A little of the phraseology, such as was used in connection with research, would have pleased us. The balance of the book is devoted to a schedule of steels which the firm has standardised. Classes S. and T., comprising 22 different compositions, cover the grades of steel made for castings, plus, of course, such material as heat, acid and rust-resisting material. They are, indeed, illuminating and show the great progress which the steel foundry has made in recent years. The last few pages of the catalogue details an imposing list of foreign agents, and concludes with a list of their trade publications. A piece of smart publicity has been achieved by including on the back cover three tear-off business reply cards, which require no stamps. The black lines these carry have been merely included in the scheme of decoration. Recipients of this catalogue, can, indeed, count themselves fortunate.

Sheffield University Metallurgical Society.

During a successful session a full quota of lectures has been contributed by students and staff. A comprehensive Paper on "Modern Foundry Practice" was read by Dr. Skerl, and Mr. Percival in an interesting lecture traced the modern developments in Pyrometry. Works visits were carried out to Messrs. Hall & Pickles High-Frequency Melting Shop, Messrs. Mappin & Webb's and Messrs. The Brightside Foundry. A similar programme has been arranged for this session.

Silico-Manganese Alloys for Deoxidising Steel.—One of the most important factors affecting the rate of elimination of non-metallic inclusions from steel is the size of the particles, since the rate of rise of these liquid particles is directly proportional to the square of their radius. Deoxidisers in the form of suitable silicon-manganese alloys result in the formation of ternary oxide combinations which have the desired composition and fluidity. Tests on ten open-hearth heats showed that particles formed on deoxidation with the proper grade of silicon-manganese alloy had a rising velocity from 1,600 to 4,000 times as great as particles formed when only silicon additions were made. The best ratio of manganese to silicon is between 4.5 to 1 and 6.0 to 1.—"Blast Furnace and Steel Plant."

Refractories.*

By J. C. Green.

The products of refractory manufacturers have a very wide application; consider for a moment some of the essential industries, and how dependent their processes are upon adequate refractories—the foundry, allied with the iron and steel and non-ferrous metal, gas, electrical, chemical, glass and pottery, and if you think what a multitude of different conditions have to be met to satisfy the requirements of all these industries, you must agree that the manufacturers' task is no easy one. In view of the obvious importance of refractories, it is rather astonishing that we in this country were so slow in really getting down to the scientific aspect of the subject. In fact, it took an upheaval of the magnitude of the Great War to stir us from our lethargy regarding the importance of research and development.

This is borne out by the fact that in November, 1917—the Faraday Society, under the presidency of Sir Robert Hadfield, held a discussion on refractory materials, primarily to arouse general attention in this country to the subject of refractories, and Sir Robert in his introductory address, reviewed the position as it was then, to use his own words: "Notwithstanding the fact that the satisfactory working of steel making, and other furnaces, as well as metallurgical operations generally, largely depends upon the correct kind of refractories employed, this important subject has not altogether received in this country the attention it should have done. A search in the proceedings of one of our leading metallurgical societies shows that there have been practically but a few Papers contributed on the subject, which is really conspicuous by its absence."

That the situation was as outlined by Sir Robert was borne out by many other speakers. There is little doubt that this meeting marked a very definite turning point in the development of refractory research in this country. From that time to the present day there has been far more interest taken in refractories, and the amount of work done individually and collectively is very large indeed. The British Refractories Research Association, under the able direction of Dr. Mellor, has led the way with much useful and valuable work. All the leading scientific societies have had many Papers presented on the subject, and the transactions of the Ceramic Society make very useful text-books for both refractory makers and users.

What has been the effect of all this work, and how much nearer we are to an ideal than when the position was reviewed by the Faraday Society in 1917? What has been the reaction on manufacturers of the wider extension of research; how has it affected users? Is the liaison between makers and users more satisfactory? Some manufacturers have responded and made an effort to cope with new conditions as they have arisen, and to be more conscious of the altering needs of users. The modern tendency in most industries has been higher temperatures, and the speeding up of melting and heating cycles.

The wide fields of application and the innumerable sets of conditions, possibly assisted by lack of co-operation between makers and users, have given rise to a very large number of different refractories for selection, and with the discovery and exploitation of the minerals cyanite and sillimanite in India, and the development of fused compound minerals such as silicon carbide, mullite and more recently siemensite, the number seems likely to increase rapidly. As yet, however, by far the most extensively used refractories are those produced from fireclay—aluminous and siliceous—and quartzite rocks.

The range of fireclay refractories has increased very considerably during the last decade, and many excellent bricks of varying analyses from the highly siliceous class containing up to 80 per cent. silica to the high-aluminous class containing 45 per cent. alumina with varying properties are obtainable. Unfortunately, there are no extensive deposits of the hydrated forms of alumina, diaspore or bauxite in this country with which to build up the alumina content, although recently deposits in Ireland sufficiently free from iron have been found and are being used by some manufacturers. In some cases considerably higher alumina content has been obtained by the addition of synthetic corundum, but if much of this material is used, the price begins to rise.

From the foregoing it will be gathered that, in selecting clays for the manufacture of better refractories, manufacturers have been impressed by the refractory qualities of alumina and silica. In the ordinary firebrick class their efforts have been to blend the clays available so as to obtain as refractory a material as possible, combined with mechanical strength and other useful physical properties. The importance of texture has not been overlooked, for assuming the chemical composition and refractoriness to be satisfactory, the control of texture to ensure definite characteristics is essential.

Textures vary from the porous insulating type of brick to the well-vitrified type built to resist abrasion, and the scouring action of slags and fluxes. To control texture it is necessary to ensure during manufacture fine grinding of the clay batch and the use of specially-prepared grog suitably graded. The maximum plasticity of the clay should be developed, and this is only attained by allowing the freshly-mined clay to remain exposed for very long periods to atmospheric conditions, and by adequate grinding and later maturing. The mixing of the clay and grog must be carried out under conditions that will in no way alter the sizes of the grog grains, otherwise the preliminary work on grog preparation will be undone.

The Danger of Buying Cheap Firebricks.

It will be appreciated that a manufacturer cannot, even with the most modern plant and equipment, manufacture a controlled product, and expect to compete in price with an uncontrolled product. The contradictory results in service so frequently heard of regarding firebricks can be accounted for by the popularity of the cheap brick made by uncontrolled methods. The controversy as to what is an ideal firebrick still goes on, and it is very questionable whether it will ever be decided. The possibility of standardising a brick to give good service under the innumerable conditions existing is very remote.

One point generally recognised to-day is that the machine-made brick is superior in every way to the hand-made brick. It is possible with modern methods of manufacture to eliminate the old faults that once existed in machine-made bricks. Spalling tendencies can be overcome by addition of grog grains suitably graded, and by firing to higher temperatures. Modern mixing of the clay and grog is very much more thorough, and the tendency to lamination is overcome. Percentages of the grog fractions in all types of bricks are generally increasing, and it is probable that the high-grog-content brick will be more generally manufactured in a few years' time.

Grog Content.

In high-grog-content bricks it is, of course, important that the grog be manufactured of good refractory material. Special methods of manufacture eliminating the chance of green grog are necessary; full details of this were given in a Paper by Mr. Threlfall before the Ceramic Society recently. Manufacturers to-day, in order to cope with the advanced ideas and new knowledge so continuously being brought forth by research, need a very much more able staff than when rule-of-thumb methods prevailed.

At the present time there are several refractory firms in this country who are making great efforts continuously to produce reliable products and who maintain fully-equipped research and testing laboratories with trained staffs. The efforts of these firms are nullified in many instances by the lack of sympathetic co-operation from industries using refractories, the gas industry being an outstanding exception.

The gas industry was the first in this country to initiate the study of conditions and to enunciate standard specifications for refractory materials to assist the makers. That they have gained their reward is evidenced by the fact that the masses of brickwork that form retort settings are giving longer life and more trouble-free service than in years gone by when lower temperatures were the rule, smaller retorts used, smaller charges and longer carbonising periods. The results of the gas-industry specifications has led to the development of silica and siliceous materials, and to-day these are used almost exclusively in modern retort settings.

In consequence the advance in the manufacture of these products has been very marked. Probably these will be the final products for retort-bench construction, either for horizontal or vertical installations; this will depend to some extent upon future developments in the industry, but no one would deny the value of the advances to date. The steelmakers who use silica bricks have unwittingly benefited from these advances. Most of the research work on silica during recent years has been carried out with the object of improving the product for use in gasworks and coke-oven plants, and the greater knowledge of silica gained thereby cannot have failed to react on the silica products for the steel industry.

Some little time ago there was reported in The Foundry Trade Journal* statements by Professor Knox, of South Wales, to the effect that instead of developing to meet increasing demands, the silica trade of this country had declined, and the implication was that British manufacturing methods were unreliable and uncontrolled. This, of course, is not the case. Professor Knox's experience with silica must have been unfortunate, for there are many reliable makes of British silica that are undoubtedly giving excellent service in steel furnaces, also in gas and coke-oven plants. It is curious that Professor Knox should single out silica refractories for his condemnation, when probably more efforts had been made to improve refractories of this class than any other.

Straight silica bricks are manufactured from quartzite rock, and there are large quantities of this material particularly suited to this purpose distributed around Great Britain. A typical ultimate analysis would be:—Silica, 98.32; titanium, 0.01; iron, 0.14; alumina, 1.08; lime, 0.04; magnesia, 0.01; potash, 0.22; soda, 0.32; and loss on ignition, 0.18 per cent.

The analysis of the rock is not sufficient indication in itself as to its suitability or otherwise for the manufacture of silica goods. The manner in which the rock breaks down, the grading and shape of the grains must be taken into account, also the ease or otherwise with which the quartz converts to the lower specific gravity forms. The rock is crushed, graded and thoroughly mixed with the bind calcium hydroxide—this is still considered the most satisfactory bind for straight silica. To give strength to the unfired bricks it is usual to add 1 per cent. of sulphite-lye liquor to the mixture.

* A Paper read before the London Branch of the Institute of British Foundrymen, Mr. C. H. Kain presiding.

* Foundry Trade Journal, January 2, 1930, page 13.

The bricks are either moulded by hand in iron moulds or pressed in a screw or lever press; if pressed, the moulds are filled with the mixture by tamping before pressure is used. The bricks after moulding or pressing are thoroughly dried, preferably in a humidity drier, and then fired.

Firing.

Efficient control of the firing schedule is a very important factor in the manufacture of silica goods. The firing must be such as adequately to bring about the transformations in quartz to the lowest specific-gravity forms, cristobalite and tridymite. The specific gravity of quartz is 2.65; cristobalite, 2.33; and tridymite, 2.27. Thus there is a considerable volume change in the bricks during firing. The temperature of firing should be at least 1,500 deg. C. and if possible 1,550 deg. C. The rate of conversion at these temperatures is very much greater than that at 1,200 or 1,300 deg. C. The peak temperature should be maintained for 12 hrs. for soaking purposes. The kiln must then be cooled with all the dampers and fire holes closed. Fine-textured bricks are stronger and more durable than coarse-textured. For steelworks use the porosity should be around 20 per cent.

A well-burned lime-bonded straight silica brick will contain a small amount of residual quartz, together with cristobalite and tridymite, and a glassy matrix of calcium, alumina as complex silicate. The brick when subsequently heated will be subject to change from three separate expansions:—(1) The normal reversible expansion; (2) reversible expansions which take place at low temperatures due to polymorphic changes in cristobalite, tridymite and quartz; and (3) an irreversible expansion due to constitutional changes of residual quartz to cristobalite and tridymite at high temperatures. The inversions take place at the following temperatures:—

α Quartz = β Quartz.
575 deg. C.
α Cristobalite = β Cristobalite.
225 deg. C.
α Tridymite = β.1. tridymite = β 2 tridymite.
117 deg. C.

These changes take place fairly rapidly and can cause dangerous strains in the brick structures, hence the absolute necessity of heating up silica constructions with extreme care.

Present Position in Foundries.

From a recent Paper by Dr. Skerl, it is gathered that conditions are not too good, due in measure no doubt to the innumerable sets of conditions that maintain. However, there are indications, from the numerous Papers and discussions recently on cupola linings, etc., that interest in the subject of foundry refractories is gaining ground. Before any great headway is made, it will be necessary to investigate very thoroughly the conditions in the different branches of the industry; it will be impossible to collect comparative data that will be of any use until this is done. Probably the quickest way to obtain results would be to follow the lead of the gas industry, by forming a joint committee of foundrymen, makers and refractory experts. By this method the possibility of personal prejudices is excluded.

The science of refractories in relation to metallurgical operations is far from being "exact"; for this reason it would be unwise to be discouraged because of individual failures and apparent contradictions which are almost bound to occur. Mr. Percival Smith and Mr. McKendrick, of Messrs. Steel, Peach & Tozer, Limited, gave a joint Paper before the Ceramic Society last year on "Refractories in Steelworks," in which they gave a summary of two years' experimenting, to make better use of refractories and their search to find refractories better suited to the needs of metallurgical furnaces called upon to do heavy duty. The conclusions arrived at after two years were less positive than would have been expected or hoped for, but the information gained over this period undoubtedly lays the foundation for very real advances in the future.

The time factor is a very great difficulty; it is so easy to lose interest, and previous records, when long periods lapse between experiments.

Cupola Linings.

The question of cupola linings has been very much in evidence in technical Papers during recent years, but has the thought and energy expended been reflected to any extent in actual practice in foundries? The question of bricking and patching *versus* ramming for cupola linings is likely to remain unsolved, as it appears that one method is good under one set of conditions and the other under another, but that does not preclude the possibility of obtaining better results with both these methods.

Regarding brick linings, there is considerable scope for experiment. The chemical composition is important, and it is the accepted opinion that bricks should contain 37 per cent. of alumina, or over, and the pyrometric core equivalent value should never be below 1,700 deg. C. The load conditions in the cupola will reduce this figure 150 to 200 deg. C., as is clearly shown in Dr. Skerl's Paper. Another important property that has probably been overlooked is vitrification. A cupola block should be hard true to shape, and well vitrified, and should be sufficiently well fired to ensure persistence of size in service. The jointing material should be chosen with care. In this respect many users are "penny wise and pound foolish," as bad jointing means the existence of many vulnerable spots where erosion and disintegration will begin. There is no excuse for using bad jointing material to-day. There are many excellent refractory cements on the market that will allow of close jointing and will knit the bricks firmly together. There is no need for the jointing material to be much less refractory than the bricks; good cements give a hard, dense, dry set.

The materials in general use for rammed linings are siliceous in character, either mixtures of silica and fireclay or natural siliceous clays, the analyses fluctuating between 80 to 93 per cent. silica and 5 to 15 per cent. alumina. Assuming the chemical composition to be all that is desired, and that the dried and fired mass will produce the necessary properties—high refractoriness, mechanical strength and resistance of fluxing—there remains the method of placing on the interior of the cupola. Though the author is not too conversant with the usual methods of ramming, he can visualise the difficulties that must exist, and realise the necessary precautions to be taken to ensure a sound uniform structure.

Cement Guns.

There is a method of placing the material, which has not been tried on cupolas in this country, and which might conceivably be successful, and would at all events ensure a uniform structure, the method being to shoot on the lining by means of the cement gun. By this method the dry mixture—silica and clay—would be shot with the necessary water at high pressure from the nozzle of a cement gun on to the walls of the cupola, thereby producing a covering of great solidity.

The amount of water added can be regulated to a nicety. When the mixture is placed, only the finest materials remain, at first, upon the surface shot against; as soon as a matrix of fine material is built up of sufficient thickness to hold the larger particles, the material placed begins to contain particles of all sizes. The "rebound," that is, material rejected, performs a valuable function in that it drives the matrix into each crevice, depression, or pore of the surface shot against. Owing to the increased density of the materials placed by this method, over the same materials placed by hand, and the fact that minimum hydration can be attained, cracking during setting, and drying is eliminated, and therefore greatly increased resistance to attack is secured.

The material dries very quickly and sets well through being applied at a high pressure (3 to 4 atmospheres). As a rough guide as to how long it would take to line a cupola, an experienced nozzleman and operator would place 25 to 30 sq. yds. 2 in. thick during an 8-hr. shift. It is possible that a cement gun in a foundry might turn out to be a very useful tool for applying the daily patch.

Daily Patching.

It seems rather extraordinary that highly-siliceous mixtures should be so generally used for patching firebrick linings. The possibility of evolving better mixtures for the patching of cupolas opens up a very big field for development. In America and possibly in Germany the cement gun is used with considerable success for the repair of soaking pits, Bessemer converters and for lining ladles.

In this country, the question as to whether ladles should be lined with brick or rammed is as controversial as the question of cupola linings. It seems to be the general opinion where brick linings are used that well-vitrified bricks, of true shape and correct dimensional size, thoroughly burnt to ensure persistance of size in service, should be used for ladle linings. Here again the jointing is of vital importance.

The linings for the rotary-powdered fuel, and oil-fired furnaces of the Sesci and Brackelsberg type are receiving a lot of attention at the present time. Rammed linings of siliceous material are general.

There is an experiment in operation now at Armstrong Whitworth's for placing the material in a Sesci furnace by means of a cement gun. The results of this experiment should be very instructive.

No mention has been made of developments in the production and use of super refractories; this subject contains enough substance for a Paper in itself. There are still many improvements to be made both in the manufacture and application of refractories, not only in the iron and steel industries, but in all industries where refractories are used.

There is no excuse for manufacturer or user remaining static regarding refractories to-day. The scientific and technical literature on the subject is voluminous. Although it may be admitted that certain advances have been made, it must be agreed that foundries have not progressed as they should. One of the main hindrances has probably been the lack of co-operation between makers and users, and the reluctance, in some instances, to reveal the true conditions the bricks will have to withstand. The obsession for cheap bricks is another deterrant—first cost is not the last cost. Prejudices and lack of imagination are also bad bankers to progress—it is a mistake to be easily satisfied.

Iron and Steel Production.

The National Federation of Iron and Steel Manufacturers, in their "Statistical Bulletin" for January, states that the number of blast furnaces in operation increased by two during January to 62, which is higher than at any time since June last; production of pig-iron at 286,600 tons was 2,100 tons higher than in December; at the end of January, 1932, there were 76 blast furnaces in operation, and the output of pig-iron was 330,000 tons. Steel production in January amounted to 444,400 tons, compared with 430,400 tons in the previous month, which had been affected by the Christmas holidays; in January, 1932, steel production was 429,700 tons.

XUM

Note on the Influence of Volatile Chlorides on Copper.*

By J. D. Grogan, B.A., and T. H. Schofield, M.Sc.

Introduction.

During the course of the investigation of the effect on the soundness of aluminium castings of treatment of the molten metal with the vapour of volatile chlorides, the influence of these materials on magnesium and on copper was also examined. This note describes the results of some experiments made in the course of the latter investigation.

Treatment of Copper with Volatile Chlorides.

The metal employed in these experiments was high-grade cathode copper of the following composition by analysis: copper, 99.96 per cent.; iron, 0.002: arsenic, 0.015; oxygen, 0.003 per cent.

Treatment under Charcoal. — Batches of 11.5 lbs. of copper were melted under charcoal and treated successively as described above with 0.3, 0.6 and 2.4 c.c. of titanium tetrachloride and 2.4 c.c. of carbon tetrachloride per lb. of metal. Copious fumes were evolved during treatment. After treatment a cylindrical casting similar to those previously described was poured in sand from each batch at approximately 1,150 deg. C. During pouring a stream of nitrogen was directed on the metal. The density of a half-section of each casting was determined, and the following results, shown in Table I, were obtained:—

Table I.—*Density of Copper after Treatment with $TiCl_4$ and CCl_4.*

C.c. per lb. of copper.		Density.
$TiCl_4$.	CCl_4.	
0	—	7.544
0.3	—	7.598
0.6	—	7.644
2.4	—	7.937
—	2.4	7.889

The cut surface of each casting was polished and etched. The treatment appeared to exert no influence on the grain-size. All the castings contained numerous blow-holes, particularly near the surface. The blow-holes were similar in character to those ascribed by Allen† to the presence of hydrogen and oxygen together in molten copper.

Treatment under Borax.

Experiments similar to those described above were carried out on copper protected by a borax flux. After treatment with 2.4 c.c. of titanium tetrachloride and carbon tetrachloride respectively, the metal was cast in a 3-in. dia. sand mould and a 1-in. dia. chill mould. Density measurements of cropped 1-in. dia. chill-bars and of halves of the sand-castings gave the following results:—

Table II.—*Density of Copper when Melted under Borax and Treated.*

Chloride used.	Density.	
	1-in. casting.	3-in. casting.
None	8.127	8.087
Titanium tetrachloride ..	7.996	7.877
Carbon tetrachloride ..	8.898	8.464

The results show that after treatment with titanium tetrachloride the metal is very unsound. This is probably due to the action of titanium tetrachloride on the flux, which became very viscous, and apparently failed to cover the metal completely, and so allowed the access of oxygen from the air to the metal. During treatment with carbon tetrachloride the flux remained very fluid.

The material treated with carbon tetrachloride gave a density figure so high that it was expected that it would possess a high electrical conductivity. To measure this the 1-in. dia. chill-bar was cold-rolled to 0.5 in. in diameter, and electrical-conductivity measurements were made on a bar machined from this rolled material both in the "as rolled" condition and also after annealing for 30 min. at 700 deg. C. The results obtained are given in Table III (bar A).

As the conductivity values were unexpectedly low, the material was analysed and found to contain the following impurities: iron, 0.080 per cent.; nickel, 0.022; insoluble, 0.007 per cent., and chromium, trace. The analysis of bar A suggested that the metal was contaminated by corrosion products derived from the nickel-chromium-iron alloy tube employed to deliver the chloride. This tube became red-hot during treatment.

To avoid excessive heating of the tube, a Salamander tube considerably longer than the inverted crucible previously employed was constructed by the Morgan Crucible Company and used in order to keep the metal tube well above the melting furnace. When this attachment was used the metal tube did not become excessively hot. Another batch of 16 lbs. of copper was treated with 3.6 c.c. of carbon tetrachloride per lb. of metal delivered through this apparatus, and castings were made as before. The following density figures were obtained: Half 3-in. dia. sand-casting, 8.545, and 1-in. dia. chill-casting, 8.920. The 1-in. dia. chill-cast bar (B) was rolled, and measurements of density and electrical conductivity were made as before. The results shown in Table III were obtained:—

Table III.—*Properties of Copper after Treatment.*

Bar no.	Condition.	Resistivity microhms/cm.³.		Relative mass conductivity. Per cent.		Density.
		20 deg. C.	65 deg. C.	20 deg. C.	65 deg. C.	
A	As rolled	2.660	2.545	76.1	67.5	8.93
	Annealed	2.215	2.500	77.4	68.6	8.93
B	As rolled	2.035	2.325	84.4	73.9	8.93
	Annealed	2.020	2.305	85.0	74.5	8.93

The conductivity values given by bar B were superior to those of bar A, but were still unsatisfactorily low. Analysis showed as impurities only 0.028 per cent. of iron and 0.0025 per cent. of oxygen. It appears, therefore, that a very small amount of iron, in the absence of sufficient oxygen to convert it into oxide, exerts an influence on the conductivity of copper more serious than that reported by Hanson and Ford.*

* Extracted from a Paper read before the Spring Meeting of the Institute of Metals.

† Journal of the Institute of Metals, 1930, 43, 81.

* Journal of the Institute of Metals, 1924. 30, 335.

Centrifugal Machine for Molten Iron Removal from Blast-Furnace Slag.—A new machine which separates molten iron from molten slag has been designed by Edgar E. Brosius, Inc., Pittsburgh, and recovers free iron in a usable form by means of centrifugal force, after which the slag is granulated. The first installation of this machine was made at the Neville Island plant of the Davison Coke & Iron Company, Pittsburgh, and is said to be doing good work. It consists of a spinning pot or centrifuge mounted on a vertical motor inside a retaining shell, with water sprays provided in sufficient number so that the slag, free of iron as it leaves the lip of the pot, is granulated. The machine is located at one end of the cinder pit nearest the furnace; at the opposite end of the pit is a platform on which the pots handled by the machine are serviced. Rings of iron recovered from the pots after a run of slag vary in size up to 3,000 to 4,000 lbs. In one instance of a flush lasting 15 min., 5,000 lbs. of iron were recovered, although no iron was apparently flowing. The machine is said to be applicable to open-hearth practice as well as blast-furnace practice and also to non-ferrous metal smelting operations.—"Steel."

Industrial Optimism.

At the annual gathering of the employees of J. G. Stein & Company, Limited, the Bonnybridge brickmakers, Colonel Stein in the course of his address said that when bad times were being experienced it was all the more necessary that they should foregather in a social capacity and spend a happy time together. He regretted that the firm had not been able to give so much employment during 1932 and that the new extension to the works which were completed about nine months ago had not yet been put into operation. They had to keep in mind in the first place that in Great Britain they were dependent to a large extent on export trade for their prosperity, and this applied particularly to Scotland. Looking round the world to their export markets they found they were very disturbed and unsettled from China to Peru and trading conditions were extremely difficult.

The United States, and to a lesser degree France, had now hoarded most of the gold in the world, and the scarcity of gold had increased its value. In other words, commodities in terms of gold had become cheaper. As a result producers, especially farmers, all the world over had not got enough for their products to cover bare costs and were in a serious plight and could not afford to buy so much of our manufactured goods. In ordinary times there was always a lot of new development work going on in the world, and the present absence of this had a serious effect on the demand for goods of all kinds, including refractories. They had built new works at Manuel during the last four years, and must have given employment to 250 men for three years in the actual construction, including production of machinery. These works now gave direct full-time employment to about 170 men, and when trade improved, this would be considerably increased. There was indirect employment to many more, including coal miners, railway men, etc. They had now to pay rates on these new works, and on any profits made 25 per cent. income-tax had to be paid.

The view had been expressed in some quarters that the large amount of unemployment was due to the increased use of machinery for mass production and that we should have to expect to carry a larger number of unemployed in the future. He had read in the papers that, with modern factories, 100 men could produce all the bricks required in U.S.A. Those in the trade knew that to be sheer nonsense, but it seemed unfortunate that reports of the kind should be spread, as they must create despondency in the minds of the unemployed.

Competition had been said to be the life blood of trade, but when other countries subsidised their industries, such as shipping, to a heavy extent, raise almost prohibitive tariffs and introduced quotas to restrict imports, it made very unfair competition, and could not, of course, continue indefinitely. Taking everything into consideration, Britain was weathering the storm better than most other countries, and instead of people emigrating, no less than 20,800 returned to our shores last year. He had no wish to minimise the tragedy of nearly three millions unemployed, even when we had a good system of insurance, but he saw no reason for despondency as to the future. We must, however, strive to improve our products, in quality, and reduce costs; in other words, to give better and better value. That was the road the firm was following, and it was still, he thought, the right road to better trade. He wished to thank all the employees for the good work that they were doing; it was comforting at this time to feel that everyone was doing his or her best. He wished especially to refer to the research staff and to assure them that their work was much appreciated. The orders so far received this year had been slightly better on the average than last year, which was not saying very much, but the feeling was that they were on the way to better times.

Cupola Control—Its Progress, Practice and Value in the Iron Foundry.

USE OF SODA ASH FEATURED.

Mr. Wharton's Paper, published in The Foundry Trade Journal of February 16, provoked an interesting discussion. It was opened by Mr. C. D. Pollard (Branch-President), who said that credit was due to Mr. Wharton for giving them so many new ideas and details of a very efficient lay-out. Not being a cupola expert himself, he (the President) appealed to members to express their opinions and promote a really good discussion.

Mr. Roxburgh said he himself was particularly interested in the balanced-blast system, as his firm were at the moment altering a cupola to the new method. On this type of cupola there was a bottom row of tuyeres and three rows of auxiliary tuyeres. To what height was the coke bed taken above the level of the bottom tuyeres? What effect had the balanced-blast cupola on the losses and gains of the various constituents of the iron, *i.e.*, loss of silicon and manganese and gain in sulphur and carbon? It was claimed that one obtained a higher temperature of metal with this type of cupola; and for this reason had it a greater effect upon the refractories used?

Mr. Wharton replied that it was usual to start with a coke bed at the height of the second row of auxiliary tuyeres. In cases where long waits were necessary, they put the coke bed to the top row of auxiliary tuyeres. With regard to the losses of the constituents of the iron itself, they had found very little difference from their ordinary practice, although he was given to understand that in malleable practice the losses in silicon and manganese were less, and they also found there was less carbon picked up. With regard to the refractories, this was a point which one had to settle for oneself. Speaking generally, where they were melting at high temperatures they must have a high refractory material. He thought that, seeing such elaborate methods of controlling the tuyeres had been introduced, they ought to modify their practice and use the best refractories possible, because in that particular type of cupola one object was to keep the cupola clean, and if they were using poor refractories it did not help things at all. Members had to decide upon the basis of cost, and that was a personal problem.

A Member asked how much refractories cost per ton of material at the spout.

Mr. Wharton replied that that was a wide question. He thought it would be found in general practice that between 4d. and 1s. 3d. was the range.

Mr. Ollerenshaw said he did not think the author had mentioned that the pressure was 9 ozs., but he did not say anything about the volume, neither had he said anything about drop bottoms and solid bottoms.

Mr. Wharton replied that the question of volume of air was a very vexed question. It was usually estimated that 30,000 cub. ft. of air was required for a ton of metal. In this case it must be considerably less, because those calculations were based on using about 2½ cwts. of coke. They could not say how many cub. ft. of air were required in this case, but it was probably somewhere in the region of 23,000 cub. ft. of air per ton of metal. With regard to solid bottoms and drop bottoms, Mr. Ollerenshaw probably knew quite as much about it as he did, but for his own part he favoured drop bottoms.

Use of Soda Ash.

Mr. Duff said the use of soda had recently become popular in quite a number of foundries. He did not know whether Mr. Wharton agreed with it or not, but nearly every American foundry at the present day used it. At his foundry it was used, and they found it very valuable. Would Mr. Wharton express his opinion about it?

Mr. Wharton replied that the question of soda was only just beginning to be touched upon in the foundry. He thought the reason it had come so much to the fore in the States was because they had probably used irons which were high in sulphur. In some foundries they had used high proportions of scrap which were high in sulphur and that had caused them to use more soda ash. Where a large amount of new pig-iron was available the problem was not so acute. He thought that some improvement in the metal could be obtained by the use of soda, but probably the amount used in the States was not required in this country.

A Member asked if the author would advise the use of soda in a receiver.

Mr. Wharton said he thought that depended upon the metal they were using. He had had no experience of such receiver practice.

The Member said he meant to ask whether he did not think it was dangerous to allow the metal to boil over.

Mr. Wharton replied that, if added dry, no violent reaction was experienced, and suggested adding soda ash as the metal ran from the spout.

Mr. Oxley said that in trying this method they found their greatest difficulty was getting rid of the slag, which was made very fluid by the action of the soda. They found, however, that the use of soda considerably reduced the sulphur content of the iron.

Mr. Roxburgh said they reduced their sulphur by 0.04 to 0.05 per cent., and the slag was very viscous indeed. They were doing this to desulphurise some iron they were going to use for special iron.

Mr. Wharton replied that the Americans used the bottom pouring ladle in some cases; and by that means overcame the trouble.

Refractory Linings.

Mr. Goddard said he was very interested in Mr. Wharton's very able remarks in his Paper, and was also very pleased to know that he had taken a very great interest in the refractory linings. Many people checked the consumption of coke and limestone, but when it came to the consumption of refractories per ton of iron melted, it was often a thing that was forgotten. In one case a man said he changed over to his present quality of ganister 20 years ago, and was not going to change again. He (the speaker) was afraid there was to be no improvement in refractory linings if that was the attitude taken. He would like to support Mr. Wharton and say he thought the days of clay used with ganister rock were coming to a close. He did not mean to say that it would end altogether, but, as everybody knew, clay would shrink and crack, and therefore, one day, he thought, free clay as a bonding material would be eliminated to a great extent. There was a fair amount of coke used in melting the cheap lining, and that was not always considered. There was a large amount of the lining which ran away to slag, and the handling of that slag was not always considered. He did not want foundrymen to think he was running them down and that they were not capable of running their foundries, because he knew they were. He was speaking generally. He would like to ask the lecturer one question. The cost of the installation of the balanced blast was unknown to him, and he had been asked if it would be a proposition to convert a cupola melting not more than 38 tons a week to balance blast.

Mr. Wharton said, with reference to the cost of the balanced-blast cupola, the gentleman who melted only 35 tons per week would have to go into the question very carefully, and he would recommend the study of a Paper* by Mr. Shephard, of Ipswich, recently published in The Foundry Trade Journal, which gave a careful analysis of the cupola conversion cost. In many cases it only meant the addition of new tuyeres and some minor alterations to the wind belt, plus the licence payable to the British Cast Iron Research Association. If Mr. Goddard would peruse the Paper he had mentioned, he would find all the information he required.

Dr. Skerl said Mr. Wharton had spoken very definitely in favour of rammed linings. He (Dr. Skerl) gave a Paper a few months ago on the same subject, but he was not quite so precise, because he had a feeling that the best lining for cupolas had not yet been evolved, and that it required a good deal of co-operation between the cupola users and the manufacturers of refractory materials to develop the linings of the brick type to a greater degree than had been done up to the present. There were certain very definite advantages in using a hard material in the form of bricks, all of definite size and shape, and which did not produce the difficulties always attendant with rammed material. It only required a little carelessness in ramming for a lot of material and a week's work to be wasted and the cupola ruined as a furnace. Rammed linings were probably going to prove the best, but he had not yet given up hope that the brick manufacturer would produce something better than was at present available. With regard to the balance-blast cupola, he did not want to say too much about it, because he was a member of the British Cast Iron Research Association. He was very sceptical about the matter when it was first mooted, but he was certain that there had been nothing brought forward for melting purposes in the foundry industry since the war which could excel it for economy and general improvement all round for iron castings. He knew some 30 cupolas had been converted or built to balance-blast type. All of them, except two engaged on special production, were working on coke ratios of 1 to 14, and some of them 1 to 17. They showed a saving of 25 per cent. of coke, cleaner metal and a lower scrap percentage. These were the facts of the situation, and they could be confirmed by anybody. With regard to the de-sulphurisation problem, he wondered what was the effect of a proper cupola management on the sulphur problem. Personally, he had a feeling that a proper attention to limestone charges would give a very high percentage of de-sulphurisation. De-sulphurisation had a very bad effect on linings of the normal type, whether in the furnace or in the ladle. The most resistant materials for soda ash were definitely the least resistant to iron slags. In conclusion he thanked Mr. Wharton for his Paper. He knew Mr. Wharton's very great knowledge of cupolas and his willingness to do anything for the production of better castings.

Mr. Steele, in proposing a vote of thanks, said he was of the opinion that if they could de-sulphurise the iron before it was out of the cupola it was much better than any addition in the ladle. With reference to the rocking or jolting of molten iron, he was wondering whether some similar action could not take place in stirring the metal. He was speaking now of metal which would shank out. Some slight agitation might also bring a similar effect as jolting in the ladle. He did think that the foundrymen were partly to blame because of the materials they used not being just up to the standard that they might be. It had been said

(*Concluded on page* 213.)

* Foundry Trade Journal, December 29, 1932, and January 5, 1933.

Heat Losses from Furnace Walls.

EFFECTS OF INSULATING COMBINATIONS.

In the course of a Paper entitled "Heat Losses from Furnace Walls," read on February 6 by Mr. J. H. Wright before a meeting of the Cleveland Institute of Engineers at Middlesbrough, the author pointed out that the successful insulation of high-temperature walls depended upon furnace control, especially in cases where the heat required was generated at higher temperatures than the refractories would withstand. Further, the full benefit of heat savings by insulation might not be realised unless the extra heat made available for the same fuel input was utilised by an increased output of heated furnace charge, or unless the heat input was correspondingly reduced. The first statement suggested that the successful insulation of, say, an open-hearth furnace roof was a possibility. From a practical standpoint, this suggestion would appear less absurd as control methods and refractories improved. Although this case might at the moment appear an ideal, there were still plenty of furnaces working under less arduous conditions upon which the use of insulation would be amply repaid.

Before insulation was contemplated, the question usually asked was: "How much heat is being lost?" Heat was lost from the exterior surfaces of heated furnace walls by the effects of radiation and convection. From a knowledge of the exterior surface temperatures, their emissive power for radiant "heat," and the convection conditions applicable, it was possible to arrive at the heat loss by calculation. This method was not new, and was in regular use in certain localities. The accuracy depended upon conditions, but in practice the simpler conditions could often be chosen or assumed, and from the results obtained, useful conclusions could be drawn bearing upon the more complicated problems encountered. The first necessity in practice was a knowledge of the exterior surface temperature.

Surface temperature (continued the speaker) must be taken by a properly-designed instrument. Ordinary mercury thermometers, when used in this direction, usually give quite futile results. Experiments have shown that base-metal thermocouples arranged on suitable lines give satisfactory results under works conditions. The temperature of the surface being known, the calculation of the heat lost per unit of area and time is very much simplified by the use of graphical charts. Under "still" air conditions —*i.e.*, in the absence of wind—the total heat loss from a surface is the sum of radiation loss plus natural convection loss. In the case of surfaces exposed to wind, the total heat loss is the sum of radiant heat loss, plus the heat removed by forced convection.

The question of the emissivity value of a surface enters into the radiant-heat-loss calculation. It is generally admitted that reliable values for the emissive powers of surfaces for radiant heat are hard to find, especially in relation to materials of furnace construction. Having need of reliable values for emissivity of firebrick surfaces over a temperature range up to 200 deg. C. (392 deg. Fah.), it was decided to experiment upon this question. This was done in the following way. The intensity of the total radiation emerging from a certain area of a uniformly heated firebrick surface was compared at definite temperatures with the radiation emitted by the same area of a "black" body at identical temperatures. The instrument used was constructed on the same lines as the well-known Féry radiation pyrometer, in which radiation is collected by a concave silver mirror at the focal point of which is a thermo junction. In this case, six thermo junctions were at the focal point, the fine wire leads being brought out radially.

It was found that the emissivity of a firebrick surface maintained at from 100 to 200 deg. C. varied between 0.85 and 0.93 in different specimens. The higher value was given by a very dirty and rough-surfaced fireclay tile. A new clean Durham firebrick of smooth surface and close texture gave the value 0.85. Other values of emissivity (100 to 200 deg. C.) were obtained as follow:—Firebrick whitewashed, 0.85 to 0.89; firebrick aluminium painted, 0.56 to 0.57; rusty and dirty boiler plate, 0.89 to 0.91; clean black steel sheet, smooth oxidised surface, 0.82 to 0.84; asbestos millboard, slightly scorched, 0.89 to 0.90. The effect of metallic aluminium paint in reducing heat loss by radiation is definitely shown here. Aluminium paint has been used in this direction on indoor steam pipes, etc., and this is no new discovery.

The foregoing experiments tend to show that the emissivity of materials normally used on furnace construction usually lies between 0.85 and 0.93 over the temperature range 50 to 200 deg. C. The value recommended by Hermansen for similar circumstances is 0.81.

Fig. 1 has been calculated to illustrate the effect of insulation. It shows the exterior surface temperatures which one would expect to find in the centre of a furnace roof, maintained at steady inner face temperatures over a wide range. The effect of four different thicknesses of firebrick is shown by curves 3, 6, 9 and 12, these figures representing firebrick thicknesses in inches. It will be seen that the firebrick itself has an appreciable insulating effect, *e.g.*, for an inner working temperature of 1,100 deg. C., 3 in. of firebrick gives an outer surface temperature of 339 deg. C., whereas 12 in. of firebrick reduces this temperature to 178 deg. C. Insulation achieved in this way is certainly not the best method, especially where the total heat capacity of the wall must be taken into consideration, for instance, furnaces which have often to be heated to maximum temperature from cold.

The four lower curves 3L, 6L, 9L and 12L illustrate the effect of 2½ in. of diatomite brick (K = 0.0005 C.G.S. unit) applied on top of the above firebrick thicknesses. Curve 3L shows that 3 in. of firebrick plus 2½ in. insulation is a better heat-saving proposition than curve 12 (*i.e.*, 12 in. of firebrick bare), the resulting surface temperature being 147 deg. C. In some cases a small thickness of refractory lagged with insulation, results in the lower face of the insulation being overheated, and this must be guarded against. A further point is that the first 3 in. of firebrick added has a greater insulating effect than have subsequent layers of the same thickness. This applies in an enhanced degree with first and subsequent layers of insulation. The first inch or two saves a bigger percentage of the total heat saved than do further layers.

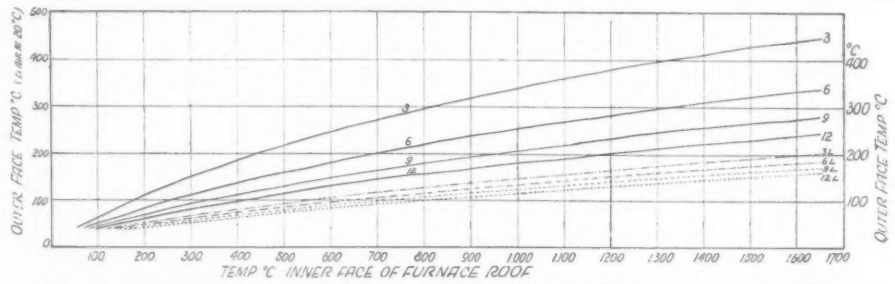


Fig. 1.—Curves showing the Effect of Insulation on Temperature of Open-Hearth Furnace Roof in Still Air at 20 deg. C.

Note.—Curves Nos. 3, 6, 9 and 12 = inches of bare firebrick (K = 0.002855 C.G.S. Unit = 8.29 B.T.U. per sq. ft. per hr. per deg. Fah. per inch of thickness). Curves Nos. 3L, 6L, 9L and 12L = inches of insulation (K = 0.0005 C.G.S. Unit = 1.45 B.T.U. per sq. ft. per hr. per deg. Fah. per inch of thickness).

Table I.—*Furnace Roof in Still Air at 20 deg. C.=68 deg. Fah. Effect of 2½-in. Insulation (K 0.0005 C.G.S. Unit.)*

Temp. of inner surface of furnace roof. Deg. C = deg. Fah.	Thickness of firebrick in roof. Inches.	Loss from roof unlagged. Pence per sq. ft. per hr.	Loss from same roof insulated. Pence per sq. ft. per hr.	Saving effected by insulation. Pence per sq. ft. per hr.	Time taken to recover outlay on insulation. Hrs. working.	Approximate max. temp. attained by insulation. Deg. C.	Time taken to recover outlay on insulation assuming 138 hours per working week.
							Weeks.
1,500 = 2,732 ..	3	0.027317	0.005846	0.021471	795	1,270*	5 to 6
	6	0.015057	0.005083	0.009974	1,711	1,115*	12 to 13
	9	0.010454	0.004453	0.006001	2,844	990	20 to 21
	12	0.008013	0.003932	0.004081	4,182	880	30 to 31
1,200 = 2,192 ..	3	0.021094	0.004592	0.016502	1,034	1,020*	7 to 8
	6	0.011729	0.004009	0.007720	2,211	900	16 to 17
	9	0.008261	0.003540	0.004721	3,615	800	26 to 27
	12	0.006367	0.003096	0.003271	5,217	710	37 to 38
1,000 = 1,832 ..	3	0.01689	0.003798	0.01309	1,304	850	7 to 8
	6	0.009598	0.003266	0.00632	2,700	740	19 to 20
	9	0.006718	0.002915	0.003803	4,485	670	32 to 33
	12	0.005237	0.002569	0.002668	6,397	600	46 to 47
800 = 1,472 ..	3	0.012890	0.003034	0.009855	1,732	690	12 to 13
	6	0.007405	0.002606	0.004800	3,556	605	25 to 26
	9	0.005278	0.002296	0.002982	5,723	535	41 to 42
	12	0.004097	0.002043	0.002054	8,310	485	60 to 61

Before leaving Fig. 1, it should be noticed that the exterior face of a 9-in. firebrick roof, unlagged, with an inner face temperature of 1,000 deg. C., is given as 206 deg. C. The addition of the 2½ in. of insulation only reduces this temperature to 125 deg. C., a reduction in temperature of 39 per cent., but the heat loss is reduced by 56.6 per cent. of the original. Although this diagram was prepared mainly on comparative

lines, it has been checked in practice, and forms a guide to the temperatures met with in the conditions stated. From the temperatures given on this diagram, the monetary savings have been calculated from the following figures:—

Fuel used: Coal. Calorific value as burnt = 13,500 B.T.U. per lb. at 13s. per ton. This gives a cost per therm of 0.516d., and per B.T.U. the cost is 0.00000516d.

Insulation used: Diatomaceous earth bricks, 9-in. by 4½-in. by 2½-in. Thermal conductivity, 0.0005 C.G.S. unit. Maximum useable temperature, 1,000 deg. C. Cost, £17 10s. per 1,000 delivered, and £20 per 1,000 as laid to give 2½-in. thickness. This gives an insulation cost of 17.066d. per sq. ft., 2½ in. thick. To cover its own cost the insulation must save over 11,300,000 B.T.U. from each sq. ft.

Table I shows that the insulation is paid for by the heat it saves in from 6 to 61 weeks of steady work in the different cases, and that after this is paid, the fuel saving varies from 0.02 to 0.002 pence per sq. ft. per hour. This may seem little until multiplied by the time and area involved. The column headed "Maximum temperature attained by insulation" shows that in the three cases marked with an asterisk, the safe temperature of the insulation is exceeded, so that if this were a practical case, the scheme would have to be modified either by use of a more refractory insulator, or a greater thickness of firebrick.

Table II.—*Heat Lost by Radiation and Convection from various types of Metallurgical Furnaces, expressed as a percentage of the Total Heat Generated (or available).*

	Per cent.	Authority.
Open-hearth steel furnaces	35 to 45	Robinson.
	41 to 48	Hadfield & Sarjant.
	61	Hubbard.
Heat-treatment and reheating furnaces	39.5	Hubbard.
	25 to 75	Hadfield.
Coke ovens	21	Killing & Theis.
Blast furnaces ..	8 to 10	Johnson.
	13	Bell.
Blast-furnace stoves	6	Killing & Theis.
	10	Clements.

Table II gives the heat lost by radiation and convection from various types of metallurgical furnaces, expressed as a percentage of the total heat available.

Conclusion.

To conclude this Paper, an impartial summary of advantages and disadvantages of insulation may be fitting. The advantages are mainly reduction of heat lost by conduction, radiation and convection, resulting in cumulative savings depending mainly upon the life of the refractory and insulation. Heat lost in this way may be reduced by 50 to 70 per cent. of the uninsulated wall loss without using great thicknesses of insulation. In certain cases this may mean a fuel saving of over 15 per cent. Reduction of no-load losses, by which is meant that insulated furnaces lose temperature less rapidly when fuel input is reduced or stopped. Evenness of temperature distribution throughout the furnace. Less time and heat required to attain working temperature. Possibility of reduction of "spalling." Reduction of total heat capacity of the wall.

The disadvantages associated with use of insulation may be summarised as follows:—Insulation in the absence of efficient furnace temperature control renders the wall more liable to overheating. The effects of overheating, either uniformly or locally, may be more widespread because of reduced temperature gradients. Insulating materials themselves are generally weak and friable. They will not withstand steam and corrosive influences, their refractoriness is low, and their capacity for absorbing moisture is exceedingly high. Ordinary magnesia asbestos mixtures as used for steam-pipe covering will generally disintegrate when used on furnace walls.

A James Watt Memorial Institute.

In 1919 Birmingham celebrated the Centenary of the death of its great citizen, James Watt. At this time a fund was raised by contributions from his admirers not only in this country but from a wider area. After paying the expenses of the commemoration, the publication of a Memorial Volume, and setting aside £5,000 for a James Watt Research Scholarship in the Department of Mechanical Engineering in the University of Birmingham, a sum of about £6,000 remained in the hands of trustees. The chairman of this body was the late Sir William Mills. The intention of the Trust was to accumulate the interest on the fund and eventually to provide a building as a Memorial to James Watt, and a home in which the various engineering societies could hold their meetings for scientific and educational purposes. Accumulation of funds proceeds but slowly, and at this time, 13 years after the centenary celebration, the Trustees, after careful inquiry, are informed that to acquire a site and to provide a suitable building in the central part of Birmingham where it would be sufficiently accessible to the members of the engineering societies, and in addition to provide an income for maintenance, would require accumulation over a very long period. Instead of postponing for an indefinite time the provision of a Memorial and a meeting place for engineers, the Trustees have decided not to build but to acquire suitable premises in the recently-erected York House to be called the James Watt Memorial Institute. The Institute will have its own entrance in Great Charles Street, and will provide a meeting hall capable of seating 200 persons, a library, cloakroom and other necessary accommodation. The capital sum in the hands of the Trustees will be kept intact, but the interest on it will be used as a contribution to the running expenses of the Institute, rent, heating, lighting, etc. The remainder of the running expenses will be provided by contributions already promised from engineering societies and from individuals. As the usefulness of the Institute becomes apparent the Trustees hope to receive additional financial support so that the facilities offered may be extended.

The Trustees very much hope that the effort they are making to commemorate the work of James Watt and to provide now a home for the various engineering societies will meet with the approval and support of those who originally subscribed to the fund in 1919.

The lease acquired is for a period of 60 odd years, but it can be broken at the end of the first five years if circumstances require this to be done owing to insufficient support for the scheme.

The accommodation, which is on the ground floor, includes a library of moderate size and will be used as a lounge and reading room with technical periodicals. The library itself will have to be built up gradually, but it may be that some of the existing engineering societies may wish to place their collection of books in this library. If the book collection becomes too large for the room now allocated, further accommodation can be acquired in the building. One room is set aside as a committee room, and if a second committee room is required at any one time this can be provided by screening off a portion of the large hall, for which purpose a permanent folding screen has been adopted.

The chief expenditure will be for rent and for services, caretaker, cleaning, heat and water. It will also be necessary to have someone as custodian to see that only accredited persons are admitted, and to make bookings for the use of the hall and committee room. This officer will at first be employed only part-time until the amount of financial support justifies payment for full-time.

The sources of yearly income at present in sight are about £400 from the capital sum in the hands of the Trustees and from other bodies and individuals as follow:—Institution of Mechanical Engineers, £100 for five years; Institution of Structural Engineers, £50 for five years; Institution of Welding Engineers, £30 for five years; Institution of Production Engineers, £20 for five years; Institute of Metals, etc., £10 for five years; General Electric Company, £20 for five years; Taylor & Challen, Limited, £25 for five years; Sir Herbert Austin, £10 for five years; Major Thomson, £5 for five years.

The South Midland Centre of the Institution of Electrical Engineers are also promising their support.

This income leaves no margin at present, but if other bodies interested in engineering support the Institute its scope and usefulness can be increased. Those who have the right of admission should be accredited members of one of the bodies subscribing.

The purpose of the Institute is the establishing of a centre for scientific and educational advancement only; it offers no other direct benefits, but it will provide splendid oportunities for self-education to all students, apprentices and other young engineers, and will also enable them to meet others of their kind who are progressing along different lines.

Joint informal meetings and discussions by students could be arranged and ideas exchanged in this way. The custodian might act the part of a liaison officer to arrange such meetings, as well as to book the hall and promote scientific intercourse between the various interests represented by the members. Firms employing such junior engineers are here reminded of the advantages they themselves would obtain through the improved knowledge of their staffs, and we appeal to such firms to recognise this viewpoint by a liberal suport to the Institute.

The Trustees are hopeful that the rooms will be finished in April, and a further announcement will be made as regards the opening. Any other engineering societies wishing to subscribe and participate in its advantages, or requiring further information, please communicate with Mr. W. B. Challen, Derwent Works, Constitution Hill, Birmingham.

The James Watt Trustees are the following:—Sir Harry Gilbert Barling, Bt., C.B., Chairman; Major S. J. Thompson, D.S.O., M.I.M.E.; Mr. John Duncan Watson, M.Inst.C.E.; Mr. R. A. Chattock, M.I.E.E.; and Mr. W. B. Challen, M.I.M.E.

Cupola Control—Its Progress, Practice and Value in the Iron Foundry.

(*Concluded from page* 211.)

that there would be by the balanced-blast a considerable saving in coke consumption. Perhaps the actual coke saving by the balanced-blast arrangement would depend largely upon the quality of the coke used. He had mentioned that to one manufacturer of coke, and the remark was that foundrymen had always demanded cheap coke, therefore they had not always been able to give them the coke necessary for the best results. That could be taken for granted, but he thought they were partly to blame in not always getting the desired results by being willing to sacrifice a little quality for £ s. d. in their materials.

Mr. Wharton briefly acknowledged the resolution of thanks.

Messrs. Baxter, Fell & Company, iron and steel merchants, 36, Leadenhall Street, London, E.C., announce that, as from January 1 last, Mr. Percy Fell has, by the effluxion of time, retired from the firm. Mr. A. T. Smith-Tyrrell, who has been associated with the firm for many years, has been admitted to partnership. The name of the firm remains unchanged.

XUM

This Week's News in Brief.

Trade Talk.

The steamer "Ford Castle," owned by the Tanfield Steamship Company, Limited, of Newcastle, has been sold to an Esthonian firm.

Messrs. Craven Bros. (Manchester), Limited, have delivered this month six of their bar parting-off, carding and centering machines, four 16-in. heavy-duty sliding, surfacing and screw-cutting lathes, and one 6¼-in. spindle horizontal boring machine.

Sir William Larke, director of the National Federation of Iron and Steel Manufacturers, was the guest of honour of the Royal Empire Society at a luncheon at the Cannon Street Hotel, London, on March 21, when he spoke on the iron and steel industry.

Dr. J. T. Dunn has been elected President of the Society of Chemical Industry for the year 1933-34, in succession to Dr. R. H. Pickard. Dr. Dunn is Public Analyst of Northumberland and represents the Fuel Research Board on the North-Eastern Coalfields Survey.

The Anchor-Brocklebank liner "Holywell," 4,867 tons, was beached at the shipbreaking yard of Messrs. P. & W. MacLellan, Limited, at Bridgeness, Bo'ness, on Friday, and her demolition will help to sustain the activity which the scrap-metal exporting trade is experiencing.

The first units of the electrical equipment for the new rolling-stock ordered by the Danish State Railways was shipped from Hull on March 10 by the English Electric Company, Limited, who are supplying the complete electrical equipment for 42 motor coaches and 21 trailer coaches.

The new turbine steamer "Brighton," which has been built to the order of the Southern Railway Company by Messrs. William Denny & Bros., Limited, Dumbarton, has completed successful trials on the Clyde. The vessel, which has been designed for a speed of 23 knots, will be placed on the New-haven-Dieppe service.

A train-load of electrical equipment left the Heaton Works, Newcastle-upon-Tyne, of Messrs. C. A. Parsons & Company, Limited, last Sunday, on a 1,220-miles' journey to Copenhagen. The machinery consists of a generating set for the Copenhagen Municipality's Örsted Power Station. The load will arrive at its destination on March 28.

Messrs. Walker & Wilson, Limited, Hamilton, are to share in the large orders for railway engineering material which have just been placed by the Chinese Purchasing Commission (London), whose function is the expenditure of about £3,000,000 of the British Boxer Indemnity on orders in Great Britain. The order is for 230 tons of fishbolts and nuts.

Seven locomotives, weighing 125 tons each, built by the North British Locomotive Company, Limited, at their Glasgow works, for H.E.H. Nizam's State Railway, India, have been shipped on the City Line steamer "City of Barcelona." The engines are almost as big as the "Royal Scot" class, and were lifted ready assembled with the exception of the tender into the ship's hold. It is understood to be the largest individual shipment ever made from the Clyde.

Messrs. J. Browett Lindley (1931), Limited, Letchworth, Herts, makers of steam engines, air compressors, condensers, etc., point out that the old company of Browett Lindley & Company, Limited, has been established at Letchworth since August, 1931, and state that over 90 per cent. of the material used in the manufacture of Browett Lindley products is made in their own foundries and machine shops, and designed, manufactured and erected by the original employees of the Browett Lindley Company.

Increased activity in the iron and steel trade is reported from Lincolnshire. The Frodingham Iron & Steel Company have started two steel furnaces in their melting shop which had been idle for some time. It is also announced that the Redbourne Iron and Steel Works, at Scunthorpe, which have been closed for two years, are expected to re-open next month. Normanby Park Iron and Steel Works, in the same district, have also received additional orders within the last few days, and shortly will be giving employment to more men.

Sir Herbert Austin presided over the inaugural meeting of the Sheffield and District Section of the Institution of Production Engineers recently. Referring to "heavy" products of Sheffield industry, Sir Herbert said there was no reason why a firm engaged in such production should not gain advantage from the efforts of a production engineer as much as a firm engaged in the manufacture of large numbers of manufactured articles. He believed we were only at the beginning of recognition by manufacturers in this country of the value of the services of really expert production engineers.

The chairman of the Sheffield Gas Company reported at the annual meeting recently that, as the result of work in their research department, a new process for the heat-treatment of high-speed and special steels had been perfected. The process was applicable to all kinds of steel, and by means of it, it was possible with a gas-heated furnace and the use of a controlled atmosphere to heat steel up to 1,350 deg. C. without the formation of scale and without decarburisation. This furnace, the chairman said, gave gas a unique advantage over any other form of fuel. They considered that the furnace had now passed the experimental stage and hoped it would soon be on the market.

The report of the International Nickel Company of Canada, Limited, for 1932 shows a net loss of $135,345, compared with a net profit of $5,094,497 for 1931. Net operating income was $3,363,400, against $9,220,309. Reflecting an improvement in business which began in the second half of the year, the final quarter of 1932 showed a net profit, after all deductions other than those for preferred dividends, of $157,008. This compares with net losses of $199,097 in the third quarter and of $629,327 in the second. Proven ore reserves stand at 203,909,973 tons. Because of this adequate tonnage, the management deemed it unnecessary to carry on other than a minimum of development work. Sales of nickel in all forms decreased by 38 per cent. and copper sales fell by 41 per cent.

Company Meeting.

Scottish Iron & Steel Company, Limited.

The annual meeting of the Scottish Iron & Steel Company, Limited, was held in Glasgow on Friday, March 17. Mr. William Downs (chairman of the company) said that the industry had just emerged from what had perhaps been the most testing of a series of years in which the iron and steel trade had been very difficult, and very depressed. Shrinkage of business was to some extent caused by the fact that the large quantities of semi-finished and finished steel purchased and delivered from the Continent in anticipation of the tariffs to be imposed in this country had not been used up; indeed, large quantities were still in stock.

"If our Government," continued the chairman, "on finding in the early days of tariffs that exceptionally large quantities of steel were still being imported, had at once placed an embargo on further imports except under special licence, the iron and steel trades might not have been so very depressed during the past year. If even now the position could be made more definite by the Government themselves taking or compelling others to take a firm stand by way of fixing agreed but reasonable national prices over a given period of time, a considerable forward step would be accomplished towards the elimination of what, after all, is very stupid and needless price-cutting competition amongst British manufacturers, and thus bring appreciably nearer the much talked-of and desirable re-organisation of the iron and steel trades of Great Britain."

Mr. Downs was of the opinion that the formation of a new International Cartel by certain Continental countries for a period of five years would have a beneficial effect on home trade. He said that "industrialists generally seemed to expect that before the year 1933 has run its course they should see the beginning of, at least, better trade. So far as this year had gone their output had been better than for the same period of last year, but they could not assure ourselves that the improvement was permanent."

Personal.

Mr. S. W. Wise, the honorary secretary of the West Yorkshire Branch of the Institute of British Foundrymen, has joined the staff of Messrs. Thos. S. Smeeth, iron and steel merchants, of Martin's Bank Chambers, Tyrrel Street, Bradford.

Mr. G. N. Guest, late managing director of Hollings & Guest, Limited, hydraulic engineers, and John Hands & Sons, Limited, power-press manufacturers, has now joined Tangyes, Limited, Cornwall Works, Birmingham, together with many of his staff.

Mr. H. F. Coggon, chairman of Messrs. August's, Limited, of Halifax, makers of August's muffle furnaces, has been elected a town councillor for the Ovenden Ward of Halifax. Mr. Coggon converted a Labour majority of 248 into a Liberal majority of 17, although he had only had five days in the Ward prior to election day.

Mr. John Neil Reid, works manager, at a social gathering of workers and friends connected with the Torwood Foundry, was presented with a silver tea and coffee service and tray and writing bureau, together with a gold wristlet watch for Mrs. Reid, to mark the occasion of his completion of fifty years' service with Messrs. Jones & Campbell, Limited.

Mr. George Chrichton, Motherwell, on his retirement from the position of chief engineer of the Motherwell Bridge & Engineering Company, Limited, Motherwell, has been the recipient of a wallet of notes from the staff and employees of the company. Mr. Chrichton, who has been in the firm's employ for over 35 years, has travelled extensively on behalf of the firm.

Mr. John Jarvie, who has just retired from the position of head of the drilling and riveting department of the Motherwell Bridge & Engineering Company, Limited, Motherwell, after nearly 35 years' service, has been presented with a wallet of notes from employees and staff. Mr. Jarvie was previously employed by Messrs. Sir William Arrol & Company, Limited, and was engaged on the building of the Forth Bridge.

Mr. William Dobbie, engineer, was made the recipient of gifts at two functions on the occasion of his leaving the service of the Shotts Iron Company, Limited. At the first, Mr. A. B. Allison, works manager, on behalf of the employees of Northfield works, presented Mr. Dobbie with a gold-mounted umbrella, suitably inscribed. At the other function, when the members of the staff met Mr. Dobbie and over which Mr. Allison presided, Mr. George Smith, chief clerk, asked Mr. Dobbie to accept a wardrobe trunk and a suitcase.

Wills.

M'Farlane, Colin, ironmoulder, Glasgow	£727
Carey, Evelyn George, A.M.I.C.E., inspecting engineer, Kyle Park, Uddingston	£74,381

Obituary.

Mr. Thomas Henry Appleton, of Clifton, York, whose death at the age of 73 is announced, was a director of Brayshaw Furnaces & Tools, Limited, Manchester.

Mr. W. W. Blunt, secretary-treasurer of the Holmes Foundry Company, of Port Huron, Michigan, whose death occurred recently, had many friends in this country. From 1902 to 1919 he served with the British Westinghouse Company at Manchester. Mr. Blunt was born in Montgomery County, Maryland. In 1896 he was appointed assistant sales manager in New York for the Westinghouse Company, and four months later was sent to London as chief engineer, an appointment he held until 1899. When the British Westinghouse Electric & Manufacturing Company, Limited, was formed, he was appointed engineer and later assistant manager. In 1906 he became one of the two general managers of the company. He was made a director and placed in charge of engineering work, which involved the design of power stations, tramway and lighting systems, industrial power plants, and miscellaneous work covered by the company in Great Britain, the British Colonies and on the Continent.

Imperial Chemical Industries, Limited, has informed its workpeople that the reduction of wages, which was made by agreement two years ago, is to be restored next month.

LET'S STICK TO FACTS:—

Fictions look after themselves.

FRODAIR

PIG IRON

Best after Test

FOR 50 YEARS

FIRST IN THE FIELD

FRODAIR IRON & STEEL CO. LTD.

Fenchurch House, London.

ESTABLISHED HALF A CENTURY.

Raw Material Markets.

Business in the iron and steel markets is still limited, but, nevertheless, the majority of the producers are taking an optimistic view with regard to the future. The stocks of foreign material that were bought before the inception of the present tariff system have been almost entirely used up, and present imports have dwindled away to a minimum. Many of the consuming works are known to be working on very small reserves of material, and only a slight quickening of the rate of industrial activity is needed in order to increase the demand for iron and steel.

Pig-Iron.

MIDDLESBROUGH.—The local demand for Cleveland iron remains steady, and there has been a gratifying increase in the demand from Scottish founders, who are benefiting from the shipbuilding orders recently placed on the Clyde. Export business is very restricted, but it is encouraging to note that two or three cargoes have recently been despatched to the Continent. Stocks are low both at the producing and consuming works, and the restarting of the Skinningrove furnaces has come at an opportune time. Local consumers are obtaining supplies delivered to their works at the following fixed prices:—No. 1 Cleveland foundry iron, 65s.; No. 3 Cleveland G.M.B., 62s. 6d.; No. 4 foundry and No. 4 forge, 61s. 6d. per ton. For other North-East Coast destinations prices are 2s. per ton more than the above figures.

The East Coast hematite market continues to enjoy a considerable demand from the British steelmakers. It has been possible to make some reduction in stocks of unsold material, but these are still very considerable. Prices in consequence remain unchanged at 59s. per ton for mixed numbers and 59s. 6d. for No. 1 quality.

LANCASHIRE.—Generally speaking, there has been no improvement in the demand for pig-iron, there being a lack of forward buying. Conditions remain unsatisfactory at the jobbing foundries. Prices are generally steady, offers of Derbyshire and Staffordshire No. 3 iron, for delivery to users in the Manchester price zone, being at 67s. per ton, with North-East Coast iron at about the same figure, Northamptonshire at 65s. 6d., Scottish foundry at around 82s., West Coast hematite at about 80s. 6d., and East Coast hematite at 5s. less.

MIDLANDS.—Conditions are irregular in the foundry industry in this district; in very few cases is it possible to report a satisfactory rate of activity. In consequence, the demand for iron is far from good, and several of the furnaces have had to make additions to their stocks. Prices for Midland brands of iron are unchanged at 62s. 6d. for Northants No. 3 and 66s. for Derbyshire, North Staffs and Lincolnshire No. 3 delivered Birmingham and Black Country stations, with the usual differences for other grades. Scottish iron still comes into this district at prices varying from 82s. 6d. to 85s. net, delivered. Medium-phosphorus irons are being offered at from 69s. to 80s. delivered. West Coast hematite is unchanged at the controlled price of 84s. 6d. delivered, but the bulk of the business has been in ordinary grades of East Coast and Welsh hematite, which vary according to analysis and tonnage from 73s. to 77s. 6d. per ton.

SCOTLAND.—Conditions in the foundry-iron market are largely unchanged, the demand remaining poor. Since the blowing-in of two furnaces at the Shotts works, there are now four furnaces in blast in Scotland; three on foundry iron and one on hematite. No. 3 Scottish foundry iron remains at the official minimum of 65s. f.o.t. furnaces, with 2s. 6d. extra for No. 1. For high-phosphorus irons the demand continues on narrow lines. No. 3 Middlesbrough is maintained at 62s. 9d. f.o.t. Glasgow area and 59s. 9d. f.o.t. Falkirk area, with Northamptonshire irons at 2s. 3d. less.

Coke.

Business remains quiet in the foundry coke market. Prices range from 36s. 6d. to 38s. 6d. for best Durham brands and from 30s. to 46s. for Welsh brands, delivered in the Birmingham area.

Steel.

Business in the steel trades appears to be gradually improving, and the usual spring demand is beginning to make itself felt, according to the official report of the London Iron and Steel Exchange. There has been more buying by stockholders, and the demand from some of the overseas markets has developed following the recent increased inquiry. The situation in the semi-finished steel department has not changed for some time, and the British works continue to hold an advantageous position. A few orders for Continental material have been placed of late, but there are not many Continental sellers in the British market at current prices. The British works, however, continue to complain of the comparatively small size to which orders are limited. In the finished-steel department more business has passed both on home and export account. The recent fall in Continental prices, however, and the movements of the exchange have enabled more business to be done in Continental material and some fair-sized orders have been placed abroad of late by consumers in this country. Nevertheless, the position of the British works seems to be gradually improving.

Scrap.

The demand for scrap iron remains strong in the Cleveland area. Ordinary heavy cast iron has sold at up to 45s. per ton, with good machinery metal at 47s. 6d. Light castings have moved up to about 39s. There is a steady demand in the Midlands and the market is firm, heavy machinery metal being offered at 47s. 6d., and heavy pipe and plate scrap at 42s. 6d. The Scottish foundries are making a steady call for suitable cast-iron scrap, which is quoted at 47s. 6d. per ton. In South Wales there is a good sale for heavy cast iron in large pieces and furnace sizes at 44s. to 45s., and for light cast iron at 38s. to 40s.

Metals.

Copper.—The demand from home consumers is rather limited at the moment, and the market is considerably influenced by overseas factors, especially the situation in the United States, where copper prices have been fluctuating after a marked rise. Electrolytic metal has been quoted on London in the neighbourhood of £32 10s. per ton.

Prices have been:—

Cash.—Thursday, £28 6s. 3d. to £28 8s. 9d.; Friday, £28 2s. 6d. to £28 3s. 9d.; Monday, £28 to £28 1s. 3d.; Tuesday, £28 3s. 9d. to £28 5s.; Wednesday, £28 1s. 3d. to £28 2s. 6d.

Three Months.—Thursday, £28 11s. 3d. to £28 13s. 9d.; Friday, £28 7s. 6d. to £28 8s. 9d.; Monday, £28 5s. to £28 6s. 3d.; Tuesday, £28 8s. 9d. to £28 10s.; Wednesday, £28 7s. 6d. to £28 8s. 9d.

Tin.—A steady business is being done with consumers in this country, the South Wales tinplate mills maintaining a moderate rate of activity. Greater interest has been taken in this metal in America, which largely accounts for the steadiness of the market during the past week or so.

Prices of standard tin have been:—

Cash.—Thursday, £149 15s. to £150; Friday, £149 7s. 6d. to £149 12s. 6d.; Monday, £148 12s. 6d. to £148 15s.; Tuesday, £148 12s. 6d. to £148 15s.; Wednesday, £148 10s. to £148 12s. 6d.

Three Months.—Thursday, £150 10s. to £150 12s. 6d.; Friday, £150 to £150 5s.; Monday, £149 10s. to £149 12s. 6d.; Tuesday, £149 10s. to £149 12s. 6d.; Wednesday, £149 5s. to £149 7s. 6d.

Spelter.—The market has been very firm, owing to a shortage of March supplies, and few consumers have been buying. Conditions on the Continent remain quiet.

Price fluctuations:—

Ordinary.—Thursday, £14 18s. 9d.; Friday, £14 16s. 3d.; Monday, £14 15s.; Tuesday, £14 12s. 6d.; Wednesday, £14 11s. 3d.

Lead.—The lead market has maintained a firmer tendency lately. Messrs. Brandeis, Goldschmidt & Company report that "there has been a fairly steady demand from consumers, although less marked than recently. Having bought freely in the last week or two, the works now appear to be fairly well covered."

Daily market prices:—

Soft Foreign (Prompt).—Thursday, £10 13s. 9d.; Friday, £10 11s. 3d.; Monday, £10 7s. 6d.; Tuesday, £10 8s. 9d.; Wednesday, £10 10s.

Company Reports.

Vickers, Limited.—Dividend for the year 1932 at the rate of 4 per cent., less tax, on the ordinary shares.

Lancashire Dynamo & Crypto, Limited.—Profit, after charging £8,873 for depreciation and £2,254 for debenture interest, £7,858; brought in, £7,802; dividend of 2½ per cent. for year, £4,875; carried forward, £8,310.

Radiation, Limited.—Profit balance, including £199,710 brought in, £488,496; to general reserve, £100,000; final dividend of 9⅜ per cent. on the ordinary shares, making 12½ per cent. for the year; carried forward, £127,442.

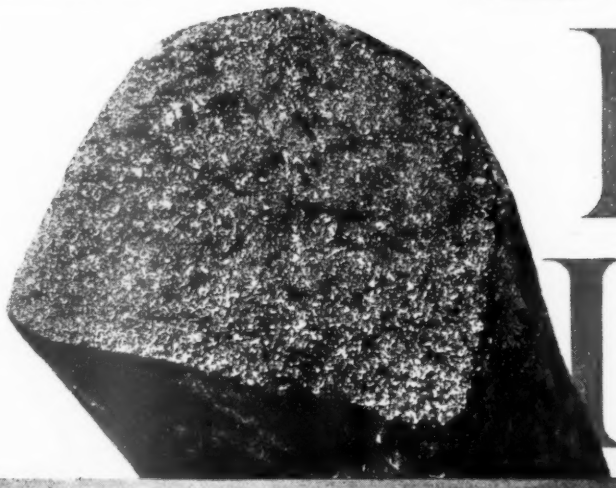
British Insulated Cables, Limited.—Profit, £589,000; brought in, £290,000; further dividend of 10 per cent. on the ordinary shares, making 15 per cent. for the year; to reserve and depreciation, £220,000; carried forward, £301,000.

Waygood-Otis, Limited.—Net profit, £89,050; brought in, £24,695; final dividend of 2½ per cent. on the ordinary shares, making 15 per cent. for the year, and a special bonus of 10 per cent.; to pensions reserve, £6,000; carried forward, £26,245.

Swan, Hunter & Wigham Richardson, Limited.—Profit, £48,558; brought in, £62,643; further dividend of 3 per cent. on the cumulative preference shares, making 6 per cent. for the year; ordinary dividend of 2½ per cent.; carried forward, £7,000.

British Aluminium Company, Limited.—Profit, including amount brought in, and after making provision for taxation, interest on the debenture stock, and setting aside £50,000 to depreciation reserve and £10,000 to the staff benefit fund, is £162,031; brought in, £49,872; dividend of 5 per cent. for the year on the ordinary shares; carried forward, after providing for preference dividend, £51,979.

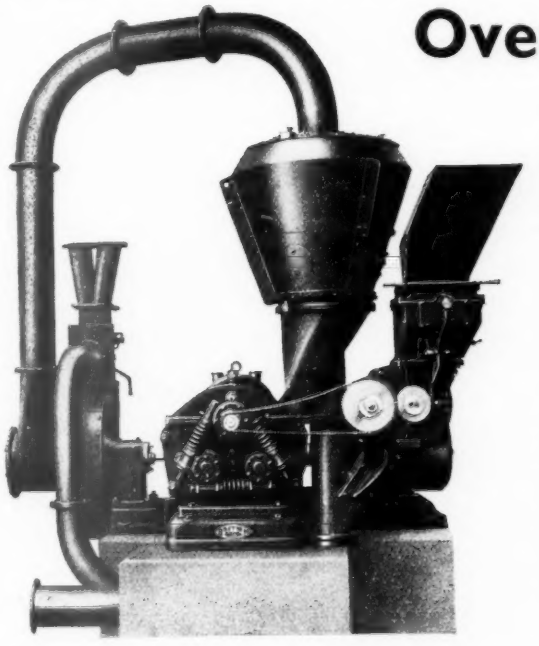
CAST IRON FLANGED PIPES
2 in.–12 in. & CONNECTIONS. to 24 in. dia.
WE HAVE FIFTY-TWO YEARS OF ACCUMULATED EXPERIENCE AND METAL PATTERNS.
JAMES & RONALD RITCHIE, LTD.,
Telephone: 3852 (2 Lines). MIDDLESBROUGH. Telegrams: "Ritchie, Middlesbrough."



PIG IRON

Manufacturers of FOUNDRY, BASIC and HEMATITE qualities. Delivery from stock.
Booklet giving analyses, etc., will be sent on request.
DORMAN LONG & CO. LTD., MIDDLESBROUGH

DORMAN LONG



British Rema Patented RW. 45 Ring Mill Unit Pulveriser. One of many supplied for firing malleable iron annealing furnaces, rotary melting furnaces, air furnaces, core ovens, etc.

Over 50% Saving in Cost

of firing Malleable Iron Annealing Furnaces is the proved result of installing the British Rema Pulverised Fuel System of firing.

Following is a typical example of conversion from hand firing to the British Rema System.

MALLEABLE IRON ANNEALING FURNACES.	Hand fired under careful supervision.	Fired by British Rema pulverised fuel unit.
Fuel consumption	9 tons per furnace charge	7 tons per furnace charge
Cost of Coal	26/- ton	9/- ton
Class of Coal	Best Hard Lump	Smudge
Cost of fuel based on 35 charges per annum	£410 } £505	£110 } £150
Labour for firing	£95 }	
Power for pulverising plant		£30 }
Repairs and Renewals to pulverising plant		£10 }

Savings in favour of British Rema Automatic pulverised fuel unit £355 per annum = 70%.

In addition to fuel and labour savings the life of the cans or containers is increased by 50% with pulverised fuel firing giving a further saving of £110 per annum.

Due to the many exclusive patented features British Rema Equipment achieves results unobtainable by other machines and methods.

THE BRITISH REMA MANUFACTURING CO., LTD.,
Hubert Street Works, HALIFAX, England.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	28	1	3
Three months	28	7	6
Electrolytic	32	10	0
Tough	29	15	0
Best selected	30	0	0
Sheets	61	0	0
India	40	5	0
Wire bars	33	5	0
Do., April	33	0	0
Do., May	32	15	0
Ingot bars	33	5	0
H.C. wire rods	35	0	0
Off. av. cash, February	28	10	6¾
Do., 3 mths., February	28	15	4¾
Do., Sttlmnt., February	28	10	6
Do., Electro, February	32	14	9¾
Do., B.S., February	31	3	9
Do., wire bars, February	32	18	6
Solid drawn tubes			9¼d.
Brazed tubes			9¼d.
Wire			6½d.

BRASS.

Solid drawn tubes	8¾d.
Brazed tubes	10½d.
Rods, drawn	7¾d.
Rods, extd. or rlld.	4½d.
Sheets to 10 w.g.	7½d.
Wire	7½d.
Rolled metal	7d.
Yellow metal rods	4½d.
Do. 4 × 4 Squares	5½d.
Do. 4 × 3 Sheets	5½d.

TIN.

	£	s.	d.
Standard cash	148	10	0
Three months	149	5	0
English	150	0	0
Bars	152	10	0
Straits	154	10	0
Australian	152	0	0
Eastern	154	0	0
Banca	154	10	0
Off. av. cash, February	148	12	7½
Do., 3 mths., February	149	1	2½
Do., Sttlmt., February	148	12	6

SPELTER.

	£	s.	d.
Ordinary	14	11	3
Remelted	14	0	0
Hard	12	0	0
Electro 99.9	17	5	0
English	15	7	6
India	13	15	0
Zinc dust	20	0	0
Zinc ashes	2	5	0
Off. aver., February	13	19	10½
Aver. spot, February	13	17	3¾

LEAD.

	£	s.	d.
Soft foreign ppt.	10	10	0
Empire	10	15	0
English	12	0	0
Off. average, February	10	11	6
Average spot, February	10	8	7½

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	24	0	0
Do., V.M. ex-whse.	23	0	0
Rods	26	0	0
Boiler plates	22	0	0
Battery plates		—	

ANTIMONY.

	£	s.	d.		£	s.	d.
English	37	10	0	to	42	10	0
Chinese					28	0	0
Crude						—	

QUICKSILVER.

	£	s.	d.
Quicksilver	9	5	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

	£	s.	d.
Ferro silicon—			
25%	8	0	0
45/50%	13	15	0
75%	19	10	0
Ferro-vanadium—			
35/50%	12/8 lb. Va.		
Ferro-molybdenum—			
70/75% carbon-free	6/3 per lb. of Mo.		
Ferro-titanium—			
23/25% carbon-free	10d. lb.		
Ferro-phosphorus, 20/25%	£17	10	6
Ferro-tungsten—			
80/85%	1/7½ lb.		
Tungsten metal powder—			
98/99%	1/10½ lb.		
Ferro-chrome—			
2/4% car.	£29	5	0
4/6% car.	£22	17	6
6/8% car.	£22	10	0
8/10% car.	£22	17	6
Ferro-chrome—			
Max. 2% car.	£34	10	6
Max. 1% car.	£36	10	0
Max. 0.70% car.	£40	2	6
70%, carbon-free	1/– lb.		
Nickel—99.5/100%	£240 to £245		
"F" nickel shot	£216	0	0
Ferro-cobalt	7/3 lb.		
Aluminium 98/99%	£100	0	0
Metallic chromium—			
96/98%	2/9 lb.		
Ferro-manganese (net)—			
76/80% loose	£10 15 0 to £11 5 0		
76/80% packed	£11 15 0 to £12 5 0		
76/80% export	(nom.) £9 15 0		
Metallic manganese—			
94/96% carbon-free	1/4 lb.		

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to $\frac{5}{16}$ in.	1/– lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅜ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/– lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP.

	£	s.	d.		£	s.	d.
South Wales—							
Heavy steel					2	5	0
Bundled steel and shrngs.	1	17	6	to	2	1	6
Mixed iron and steel	2	0	0	to	2	1	6
Heavy cast iron	2	4	0	to	2	5	0
Good machinery	2	8	0	to	2	10	0
Cleveland—							
Heavy steel					2	5	0
Steel turnings					1	12	6
Cast-iron borings					1	3	6
Heavy forge					2	10	0
W.I. piling scrap					2	2	6
Cast-iron scrap	2	5	0	to	2	7	6
Midlands—							
Light cast-iron scrap	1	18	6	to	2	0	0
Heavy wrought iron					2	8	6
Steel turnings, f.o.r.					1	7	0
Scotland—							
Heavy steel	1	18	9	to	2	0	0
Ordinary cast iron					2	7	6
Engineers' turnings					1	11	6
Cast-iron borings					1	12	6
Wrought-iron piling					2	5	0
Heavy machinery					2	11	3

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	21	0	0
Brass	16	0	0
Lead (less usual draft)	9	10	0
Tea lead	8	0	0
Zinc	8	10	0
New aluminium cuttings	74	0	0
Braziery copper	19	0	0
Gunmetal	18	0	0
Hollow pewter	80	0	0
Shaped black pewter	60	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	65/–
Foundry No. 3	62/6
„ at Falkirk	59/9
„ at Glasgow	62/9
Foundry No. 4	61/6
Forge No. 4	61/6
Hematite No. 1, f.o.t.	59/6
Hematite M/Nos., f.o.t.	59/–
N.W. Coast—	
Hem. M/Nos. d/d Glas.	68/6
„ d/d Birm.	84/6
Malleable iron d/d Birm.	115/–
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	62/–
„ No. 3 fdry.	66/–
Northants forge	58/6
„ fdry. No. 3	62/6
„ fdry. No. 1	65/6
Derbyshire forge	62/–
„ fdry. No. 3	66/–
„ fdry. No. 1	69/–
Scotland—	
Foundry No. 1	67/6
„ No. 3	65/–
Hem. M/Nos. d/d	66/–
Sheffield (d/d district)—	
Derby forge	59/6
„ fdry. No. 3	63/6
Lincs forge	59/6
„ fdry. No. 3	63/6
E.C. hematite	73/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	67/–
Staffs fdry. No. 3	67/–
Northants fdry. No. 3	65/6
Cleveland fdry. No. 3	67/–
Dalzell, No. 3 (special)	102/6 to 105/–
Glengarnock, No. 3	82/–
Clyde, No. 3	82/–
Monkland, No. 3	82/–
Summerlee, No. 3	82/–
Eglinton, No. 3	82/–
Gartsherrie, No. 3	82/–
Shotts, No. 3	82/–

FINISHED IRON AND STEEL.

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£	s.	d.		£	s.	d.
Bars (cr.)	9	0	0	to	9	15	0
Nut and bolt iron	7	10	0	to	8	0	0
Hoops	10	10	0	to	12	0	0
Marked bars (Staffs) f.o.t.					12	0	0
Gas strip	10	10	0	to	12	0	0
Bolts and nuts, ¾ in. × 4 in.	12	10	0				
Steel—							
Plates, ship, etc.	8	15	0	to	8	17	6
Boiler plts.	8	0	0	to	9	0	0
Chequer plts.					10	7	6
Angles					8	7	6
Tees					9	7	6
Joists					8	15	0
Rounds and squares, 3 in. to 5½ in.					9	7	6
Rounds under 3 in. to ⅜ in. (Untested)				6	15	0	& up.
Flats—8 in. wide and over					8	12	6
„ under 8 in. and over 5 in.					8	17	6
Rails, heavy	8	5	0	to	8	10	0
Fishplates					12	0	0
Hoops (Staffs)				9	10	0	& up.
Black sheets, 24g. (10-t. lots)					9	10	0
Galv. cor. shts.			„		11	15	0
Galv. flat shts.			„		12	5	0
Galv. fencing wire, 8g. plain					14	0	0
Billets, soft	5	0	0	to	5	7	6
Billets, hard	6	12	6	to	7	2	6
Sheet bars	4	15	0	to	5	2	6
Tin bars					4	15	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	10½d.
Sheet to 10 w.g.	11½d.
Wire	11½d.
Rods	10½d.
Tubes	15d.
Castings	12½d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	13.34
No. 2 foundry, Valley	14.50
No. 2 foundry, Birm.	11.00
Basic	15.39
Bessemer	16.89
Malleable	16.39
Grey forge	16.39
Ferro-mang. 80%, seaboard	68.00
O.-h. rails, h'y, at mill	40.00
Billets	26.00
Sheet bars	26.00
Wire rods	35.00
	Cents.
Iron bars, Phila.	1.86
Steel bars	1.60
Tank plates	1.60
Beams, etc.	1.60
Skelp, grooved steel	1.60
Steel hoops	1.55
Sheets, black, No. 24	2.00
Sheets, galv., No. 24	2.60
Wire nails	1.85
Plain wire	2.10
Barbed wire, galv.	2.35
Tinplates, 100-lb. box	$4.25

COKE (at ovens).

Welsh foundry	20/– to 22/6
„ furnace	16/– to 16/6
Durham and Northumberland—	
„ foundry	21/– to 25/–
„ furnace	13/3
Midlands, foundry	—
„ furnace	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	15/9 to 16/–
„	28×20 „	31/6 to 32/–
„	20×10 „	22/7½ to 23/–
„	18¾×14 „	16/4½ to 16/7½
C.W.	20×14 „	14 9
„	28×20 „	29/3 to 29/6
„	20×10 „	19/10
„	18¾×14 „	14/–

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6	0	0	to	£7	0	0
Bars-hammered, basis	£16	10	0	to	£17	0	0
Bars and nail-rods, rolled, basis	£15	17	6	to	£16	5	0
Blooms	£10	0	0	to	£12	0	0
Keg steel	£32	0	0	to	£33	0	0
Faggot steel	£18	0	0	to	£23	0	0
Bars and rods dead soft, st'l	£10	0	0	to	£12	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.	
Mar. 16	..	28	6	3	No change
,, 17	..	28	2	6	dec. 3/9
,, 20	..	28	0	0	,, 2/6
,, 21	..	28	3	9	inc. 3/9
,, 22	..	28	1	3	dec. 2/6

Electrolytic Copper.

		£	s.	d.	
Mar. 16	..	32	15	0	dec. 10/-
,, 17	..	32	10	0	,, 5/-
,, 20	..	32	5	0	,, 5/-
,, 21	..	32	10	0	inc. 5/-
,, 22	..	32	10	0	No change

Standard Tin (cash).

		£	s.	d.	
Mar. 16	..	149	15	0	inc. 17/6
,, 17	..	149	7	6	dec. 7/6
,, 20	..	148	12	6	,, 15/-
,, 21	..	148	12	6	No change
,, 22	..	148	10	0	dec. 2/6

Tin (English ingots).

		£	s.	d.	
Mar. 16	..	151	0	0	inc. 20/-
,, 17	..	150	15	0	dec. 5/-
,, 20	..	150	0	0	,, 15/-
,, 21	..	150	0	0	No change
,, 22	..	150	0	0	,, ,,

Spelter (ordinary).

		£	s.	d.	
Mar. 16	..	14	18	9	No change
,, 17	..	14	16	3	dec. 2/6
,, 20	..	14	15	0	,, 1/3
,, 21	..	14	12	6	,, 2/6
,, 22	..	14	11	3	,, 1/3

Spelter (Electro, 99.9 per cent.).

		£	s.	d.	
Mar. 16	..	17	7	6	inc. 2/6
,, 17	..	17	5	0	dec. 2/6
,, 20	..	17	5	0	No change
,, 21	..	17	5	0	,, ,,
,, 22	..	17	5	0	,, ,,

Zinc Sheets (English).

		£	s.	d.	
Mar. 16	..	24	0	0	No change
,, 17	..	24	0	0	,, ,,
,, 20	..	24	0	0	,, ,,
,, 21	..	24	0	0	,, ,,
,, 22	..	24	0	0	,, ,,

Lead (English).

		£	s.	d.	
Mar. 16	..	12	5	0	No change
,, 17	..	12	0	0	dec. 5/-
,, 20	..	11	15	0	,, 5/-
,, 21	..	11	15	0	No change
,, 22	..	12	0	0	inc. 5/-

AVERAGE MONTHLY PRICES OF STEEL SHIP PLATES (NORTH OF ENGLAND).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1897	5 10 0	5 10 0	5 10 0	5 7 6	5 2 6	5 2 6	5 0 0	5 0 0	5 0 0	5 0 0	5 7 6	5 10 0	5 5 5
1898	5 10 0	5 8 9	5 8 9	5 10 0	5 16 3	5 18 9	5 17 6	6 0 0	6 2 6	6 5 0	6 10 0	6 15 0	5 18 6½
1899	6 15 0	7 0 0	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 12 6	7 12 6	7 12 6	7 12 6	8 0 0	7 6 5½
1900	8 0 0	8 0 0	8 2 6	8 5 0	8 7 6	8 7 6	8 7 6	8 0 0	8 0 0	8 0 0	7 10 0	7 0 0	8 0 0
1901	6 15 0	6 15 0	6 5 0	6 0 0	6 0 0	6 0 0	6 0 0	6 5 0	6 7 6	6 5 0	6 0 0	6 0 0	6 4 4
1902	5 17 6	5 12 6	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 10 0	5 14 7½
1903	5 10 0	5 10 0	5 15 0	6 0 0	6 0 0	6 0 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 10 0	5 13 11
1904	5 7 6	5 10 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 11 10
1905	5 15 0	5 17 6	5 17 6	5 17 6	5 17 6	5 17 6	5 17 6	6 0 0	6 10 0	7 0 0	7 0 0	7 0 0	6 2 3½
1906	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 10 0	7 0 10½
1907	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 0 0	7 0 0	7 8 4
1908	6 10 0	6 10 0	6 10 0	6 5 0	6 5 0	6 5 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 3 9
1909	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	5 15 0	5 15 0	5 15 0	6 0 0	6 0 0	6 0 0	6 0 0	5 18 9
1910	6 5 0	6 5 0	6 7 6	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 2
1911	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 18 4	6 15 3½
1912	7 3 9	7 5 0	7 5 0	7 12 6	7 15 0	7 15 0	7 15 0	8 0 0	8 0 0	8 0 0	8 2 0	8 5 0	7 14 10
1913	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	8 5 0	7 19 0	7 15 0	7 3 0	6 15 0	6 10 0	7 16 5½
1914	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 0 0	6 0 0	7 0 0	7 5 0	7 5 0	7 6 3	7 10 0	6 14 8½
1915	8 0 0	8 10 0	9 0 0	9 10 0	9 10 0	10 0 0	10 0 0	10 0 0	10 0 0	10 5 0	10 5 0	11 0 0	9 12 11
1916	11 7 6	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 9 2
1917	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 6
1918	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0	11 10 0
1919	11 10 0	14 0 0	14 0 0	14 0 0	17 0 0	17 7 6	17 15 0	18 5 0	18 5 0	18 5 0	19 12 6	21 5 0	16 15 5
1920	22 10 0	23 10 0	23 10 0	23 10 0	23 10 0	23 10 0	23 10 0	23 10 0	24 0 0	24 10 0	24 5 0	24 5 0	23 13 4
1921	23 5 0	22 10 0	20 4 0	19 0 0	19 0 0	17 0 0	15 0 0	14 15 0	13 12 0	12 5 0	10 10 0	10 10 0	16 9 3
1922	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 4 0	10 0 0	9 7 6	9 4 0	9 5 0	9 5 0	9 5 0	9 18 4½
1923	9 7 6	9 15 0	10 5 0	10 10 0	10 10 0	10 10 0	9 18 9	9 17 6	9 17 6	9 17 6	9 18 6	10 6 10½	10 1 2½
1924	10 1 6	9 18 1½	9 17 6	9 17 6	9 17 6	9 19 4½	10 5 0	10 5 0	10 5 0	9 19 0	9 15 0	9 15 0	9 19 7½
1925	9 14 0	9 10 0	9 10 0	9 1 3	9 0 0	9 0 0	8 17 0	8 13 1½	8 7 6	8 5 6	7 16 3	7 14 3	8 15 8½
1926	7 12 2½	7 12 6	7 12 6	7 14 4½	7 15 0	7 16 10½	8 2 6	8 2 6	8 4 0	8 12 6	8 12 6	8 16 3	8 1 1½
1927	8 17 6	8 17 6	8 11 6	8 7 6	8 6 3	8 5 0	8 5 0	8 3 9	8 2 6	8 2 6	8 5 0	8 5 0	8 7 5
1928	8 2 6	8 5 0	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 7 6	8 6 10½
1929	8 7 6	8 7 6	8 7 6	8 7 6	8 10 6	8 12 6	8 12 6	8 12 6	8 12 6	8 12 6	8 12 6	8 13 9	8 10 9½
1930	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0
1931	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0
1932	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0	8 15 0
1933	8 15 0	8 15 0	—	—	—	—	—	—	—	—	—	—	—

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A VACANCY will shortly occur in a well-established, modern high-production foundry, situated in the Midlands, for a Foreman Fatternmaker. Experience necessary in wood plaster and lead; floor plates, match plates, machine plates, including Bonvillain process. Accurate work is essential. Applicants must be thoroughly acquainted with the light-casting industry, well able to systemise and control labour. The position will be permanent to the right man.—Apply, stating age, experience, references (if any), salary required, in confidence, to Box 362, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY Foreman wanted, age 28/30, for a large light-castings foundry in Midlands, preferably with technical and commercial experience, knowledge of plate and general moulding and latest cupola practice; good organiser, capable of tactfully handling 3/400 men. Applicants must state clearly their experiences in detail.—Box 374, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

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Conducted by the Institute of British Foundrymen by courtesy of the proprietors of The Foundry Trade Journal.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

POSITION required as Foreman in iron or steel foundries. Has held position as Foreman in first-class steel foundry, and also had good iron-foundry experience in general castings, high-class repetition work, motor cylinders, etc.; accustomed to quoting; good cupola practice. (209)

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PATENT NUMBER 296863.

IT has come to the notice of the Proprietors of the "'Styles' Patent System of Moulding" that their Patent No. 296863, dated July 22, 1927, in respect of "Improvements in and relating to Foundry Moulding and Apparatus therefor," has been infringed. The Proprietors, therefore, give notice that any firm so infringing hold themselves liable to be proceeded against.

The Proprietors are willing to consider entering into arrangements by way of Licence or otherwise on reasonable terms for the purpose of exploiting the above Patent and extending its practical working.—Box 376, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

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FOUNDRY PLANT FOR SALE.

Pneulec Rotary Sand Drying Plant, output 1 ton per hour.

No. 9 "Ajax" Pneumatic Jarr Ram Turnover P.D. Moulding Machine.

Sand Mill, 6 ft. dia., Stationary Self-discharging Pan.

"Titan" Cupola, 4 to 5 tons; little used.

Brearley Type Sand Disintegrator.

The above are offered at LOW PRICES before removal.

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250-lb. MORGAN Coke-fired Tilting Furnace.
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Tilghman Sand Blast Room, 6 ft. x 6 ft. x 8 ft. high.

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Tilghman Rotary Double Barrel Plant, barrels 24 in. x 20 in.

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Tilghman 30-in. dia. Cabinet Plant.

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Each Plant complete with Sand Apparatus, Air Compressor and Exhaust Fan.

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